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# SCIENCE

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# SCIENCE

Vol. 104, No. 2704 Friday, 25 October 1946


## The Transuranium Elements


Glenn T. Seaborg

*Department of Chemistry and Radiation Laboratory, Department of Physics, University of California, Berkeley*


THE MANUFACTURE OF THE ATOMIC BOMB involved the solution of an extensive list of extremely interesting scientific problems, and this work will occupy an important place relative to the existing scientific literature when the day for publication arrives. In the present discussion I shall review some of these interesting developments that have come about in connection with the Atomic Bomb Project. As a result of the limitations on the permissible subjects for discussion a great deal must, of course, be left unsaid.

The statements which follow will be directed largely toward a description of chemical developments. The main thesis will be the transuranium elements—that is, the elements with atomic numbers 93, 94, 95, and 96, all of which have been discovered within the last five or six years. The discussion will center around the first isolation of transuranium elements and early techniques which were developed for this work, which was done in all cases with amounts weighing a few micrograms or less. Since much of this work was done in conjunction with the plutonium manufacturing process, my statements, so far as atomic energy is concerned, will deal largely with the new synthetic element, plutonium, rather than $U^{235}$, the other material which is of importance to atomic energy.

The first transuranium element was discovered by E. M. McMillan and P. H. Abelson (*4*) at the University of California in May 1940. Using the neutrons from the cyclotron of E. O. Lawrence, they were able to show, on the basis of their chemical and physical experiments, that a beta-particle-emitting radioactivity of 2.3 days half-life formed during the irradiation of uranium with neutrons is due to the isotope $93^{239}$, which is the decay product of the 23-minute $U^{239}$ formed by radiative neutron capture in $U^{238}$. Their experiments on the tracer scale showed that element 93 has at least two oxidation states, an upper state (or states) and a lower state (or states), with chemical properties quite analogous to the VI and IV (or III) forms of uranium. For example, they showed that the $93^{239}$ under reducing conditions is carried from aqueous solution by lanthanum fluoride, while under oxidizing conditions it is not carried, indicating that the fluoride of the lower oxidation state of element 93 is insoluble and the fluoride of the higher state is soluble. They found that a greater oxidizing power is required to oxidize element 93 to its upper state than is the case for the corresponding oxidation of uranium. Later, McMillan named element 93 neptunium in recognition of its position beyond, and chemical similarity to, uranium, after the planet Neptune, which lies immediately beyond Uranus.

This early work on neptunium was done by the so-called "tracer" technique, and a few words in description of this method are worth while. The tracer method of investigation of the chemical properties of radioactive elements uses amounts so small as to be unweighable, and the course of the element in the reactions is followed by means of its radioactivity rather than by chemical analysis. Thus, the orders of magnitude of solubilities of the compounds of the radioactive element are inferred on the basis of "carrying" experiments, it being generally true that trace amounts are carried well only if the anion of the precipitate forms an "insoluble" compound with the cation being carried. A great deal about the chemical properties of an element can be learned by this method of investigation, which is the only possible method when only submicrogram amounts are available. However, care must be taken in interpreting the data, and in many cases completely positive deductions cannot be made. It is important for the purpose of this discussion to understand the difference between this tracer method and the methods of ordinary chemistry wherein the element is studied at ordinary concentrations, so that the element itself may be precipitated in pure form rather than with carrier material.


Presented as an invited paper at the Chicago meeting of the American Physical Society, 21 June 1946.

After the discovery of neptunium, the next transuranium element to be discovered was that of atomic number 94, the work being done at the University of California (*6, 7*) during late 1940 and early 1941. The particular isotope involved was that of mass 238, formed by the deuteron bombardment of uranium in the cyclotron of E. O. Lawrence. This led to the identification of a new isotope of neptunium, later shown to be the 2.0-day beta-particle emitter, $Np^{238}$, formed from a (d,2n) reaction on $U^{238}$. This isotope of element 93 decays to an alpha-emitting isotope of element 94 ($94^{238}$), and this alpha-emitter has a half-life of about 50 years. The early experiments on the chemistry of element 94 employed this isotope and were, of course, performed by tracer techniques. These showed that element 94 also has at least two oxidation states, an upper state (or states) and a lower state (or states). It was found that even stronger oxidizing agents are required to oxidize element 94 to the upper state than is the case for neptunium. Element 94 was given the name plutonium to follow the convention which was used in the naming of neptunium.

The isotope of plutonium which is of major importance is, of course, the isotope of mass 239. This isotope, $Pu^{239}$, which is the daughter of the 2.3-day $Np^{239}$, was discovered at the University of California (*1*) in March 1941. It is an alpha-emitter with a half-life of about 24,000 years. Its tremendous importance stems from its property of being fissionable with slow neutrons, a property which places it in a class of importance comparable with that of $U^{235}$.

Once the value of the isotope $Pu^{239}$ was thus definitely established, the paramount problem was that of producing it on a large scale, and the story of the accomplishment of this is, of course, the story of the Plutonium Project. The advantages of an isotope like $Pu^{239}$ for mass production can readily be seen because the separation problem here resolves itself into chemical separation of elements, plutonium from uranium and fission products; whereas, in the case of the production of the isotope $U^{235}$, it is necessary to resort to the complex and laborious procedures of isotope separation.

In order to understand the problem, let us summarize the reactions of the two isotopes of uranium with neutrons:

(1) $U^{235} + n \longrightarrow$ fission products + neutrons + energy
(2) $U^{238} + n \longrightarrow U^{239} \longrightarrow Np^{239} \longrightarrow Pu^{239}$.

One of the questions which posed itself immediately was the following: Is it possible by use of the mixture of the uranium isotopes as it occurs in natural uranium, consisting of about 0.7 per cent of $U^{235}$ and 99.3 per cent of $U^{238}$ by weight, to cause a chain reaction to occur on a very large scale? If so, the extra neutrons produced in the fission of $U^{235}$ would be absorbed by $U^{238}$ to form the desired isotope, $Pu^{239}$, in large quantity.

The other question which of necessity came up for immediate discussion was: Would it be possible to devise in a reasonable period of time chemical means for separating this $Pu^{239}$ from the uranium and from the tremendous fission product radioactivities due to the dozen or more fission product elements which would be present with it?

These were the two staggering problems which formed the basis of the Plutonium Project. Their solutions were to a large extent unrelated, and the development program in connection with each of these problems was, of course, in the hands of research men in different fields, physics and chemistry.

It is beyond the scope of the present discussion to give a description of the development of the chain-reacting units called "piles" for the production of plutonium. This work had its origin at Columbia University. Fermi and Szilard were the first to recognize that the proper balance in the absorption of the secondary fission neutrons could be obtained in a heterogeneous lattice arrangement in which the uranium is distributed in solid pieces in a more or less regular pattern throughout a graphite base. The graphite serves to slow down the fast neutrons produced in the fission reaction without absorbing them appreciably, and the two reactions listed above take place predominantly with the slowed neutrons.

The early work of the chemistry group at the University of California formed the basis for the later development of the separation process. The process now used in the separation of plutonium from uranium and fission products in the large manufacturing plants is based upon the use of the two oxidation states of plutonium, and a great deal of the earliest work was concerned with the study of these states on the tracer scale.

Early in 1942 physicists who had been working on the development of the chain reaction, and chemists who had been working on the development of separation processes for the plutonium, assembled at the Metallurgical Laboratory of the University of Chicago. In time, of course, many other scientists—chemists, physicists, engineers, biologists, and medical men—assembled here, as there soon arose many other problems related to those described above which had to be solved—problems in the fields of radiation chemistry, fission product chemistry, analytical chemistry, etc. M. Burton, C. D. Coryell, G. E. Boyd, and their groups investigated and solved these many chemical problems which were vital to the success of the enterprise. F. H. Spedding, of Iowa State College, and J. Franck, W. C. Johnson, and T. R.

Hogness, all of the University of Chicago, served at various times as directors of the Chemistry Division of the Metallurgical Laboratory. The important chemical work which took place at the large government plants connected with the Plutonium Project,

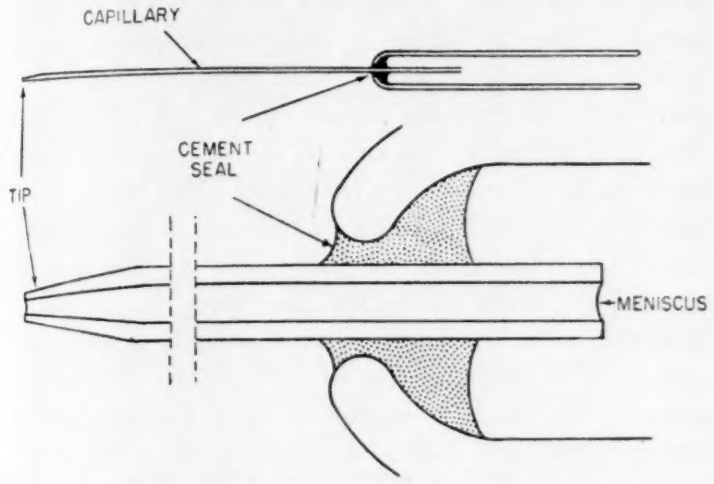


FIG. 1. Ultramicro volumetric pipette.

*i.e.* the laboratories at Clinton, Tennessee, Hanford, Washington, and Los Alamos, New Mexico, also can be only mentioned here.

Although the work on the development of a separation process at the Metallurgical Laboratory continued on the tracer scale, it was essential that a process for plant operation should have a prior test under conditions where the plutonium concentration would be the same as that anticipated in the production plants. It must be remembered that up to this time no one had seen any plutonium, and all the deductions as to its chemistry had been made on the basis of what might be called secondary evidence—that is, through tracer chemistry. Although the outline of a chemical separation process could be obtained by tracer scale investigations, the process could not be defined with certainty until it could be studied at the actual concentrations of plutonium which would exist in the large-scale separation plants. It was realized that obtaining plutonium from the chain-reaction units was still more than a year away. Nevertheless, the design of the separation plants had to begin immediately so that their construction could take place at the same time as the construction of the chain-reacting units.

The question, then, was as follows: How could the separation process be tested at the concentrations of plutonium which would exist several years later in the production plants when, at this time, there was not even a microgram of plutonium available? This problem was solved through an unprecedented series of experiments encompassing two major objectives. First, it was decided to attempt the production of an actually weighable amount of plutonium by bombarding large amounts of uranium with the neutrons from cyclotrons. It must be remembered that never before had weighable amounts of transmutation products been produced with any particle-acceleration machine. Even extending this possibility to the limit, it was not anticipated that more than a few micrograms of plutonium could be produced. The second aspect of the

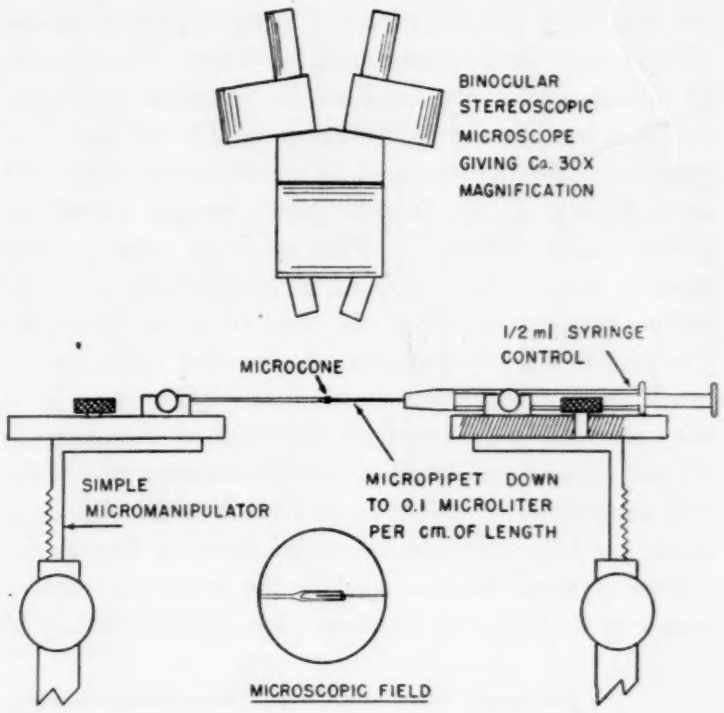
BINOCULAR STEREOSCOPIC MICROSCOPE GIVING Ca. 30X MAGNIFICATION
1/2 ml. SYRINGE CONTROL
MICROCONE
SIMPLE MICROMANIPULATOR
MICROPIPET DOWN TO 0.1 MICROLITER PER cm. OF LENGTH
MICROSCOPIC FIELD

FIG. 2. Assembly for studying precipitation reactions on the microgram scale.

solution of this problem involved the novel idea of attempting to work with only microgram amounts of plutonium but, at the same time, at ordinary concentrations. It was decided to undertake a program of investigation involving volumes of solutions and weighings on a scale of operations much below that of ordinary microchemistry.

By using extremely small volumes it was possible to arrange matters so that even microgram quantities could give relatively high concentrations, and by developing balances of the required sensitivity, micrograms were sufficient for quantitative gravimetric measurements. The field which embraces the chemical study of material on this minute scale of operation has been given the name "ultramicrochemistry" by P. L. Kirk. The pioneer investigations of P. L. Kirk and A. A. Benedetti-Pichler in the fields of quantitative and qualitative analysis on the microgram scale were of the greatest value in providing a background of manipulative techniques for the problem at hand.

I should like to give a brief description of the techniques used on this microgram scale or ultramicrochemical scale of operation. The extremely small volumes, of the order of $10^{-1}$ to $10^{-5}$ ml., are handled with the help of specially constructed, small capillary containers, pipettes, burettes, micromanipulators, etc. Liquid volumes in the range quoted are measured

within an error of less than 1 per cent by means of finely calibrated capillary tubing, the movement of liquid within the capillary being governed by air pressure under sensitive control. The smaller pipettes may be constructed to fill automatically by capillary attraction (Fig. 1). The "test tubes" and "beakers" for this work are constructed from capillary tubing which has an inside diameter of 0.1–1 mm. The weights of solids which are handled in reagents and precipitates are usually in the range of 0.1–100 μg. For purposes of comparison it is worth mentioning that an ordinary U. S. 10-cent piece weighs about 2.5 grams (2,500,000 μg.). This work is usually done upon a mechanical stage of a microscope, with the entire apparatus within the field of view (Fig. 2). The test tubes, pipettes, etc. are handled by means of mechanical aids known as micromanipulators. It is very interesting to note that precision of the order of 0.5 per cent is readily obtainable in work on this scale. The separation of solids from liquids is usually done by means of centrifugation rather than by filtration.

One type of balance used in the weighing experiments is the Salvioni balance (Fig. 3), consisting of

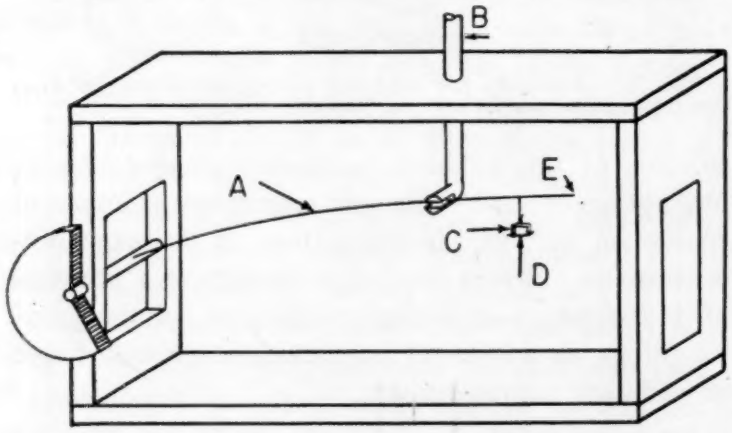


FIG. 3. Salvioni balance, with a sensitivity of 0.02 μg., a weighing range of 20 μg., and a capacity of 0.5 mg.: A—quartz fiber (about $4 \times 10^{-3}$ inches in diameter); B—adjustable stop used in loading; C—aluminum cradle for weighing pan (weight, about 200 μg.); D—platinum weighing pan (weight, about 150 μg.; about 1.5 × 2 mm.); E—position of fiber read by a reading microscope (accurate to about 0.002 mm.).

a very thin quartz fiber, fastened to a solid base at one end, to which is attached at right angles at the other end a small holder for the sample to be weighed. The measurement of the weight of the sample depends upon the measurement of the amount of bending of the quartz fiber arm, and the balance is usually calibrated by the use of known weights.

Another type of ultramicrobalance used in a number of these investigations has an extremely high sensitivity (*2*). This balance can weigh amounts as small as 1 μg. or less with an accuracy of 0.02 μg. (Fig. 4). The material can be in containers weighing at least as much as 25 mg., *i.e.* 25,000 μg. The beam and other operating parts of this balance are constructed of fibers of pure quartz ranging in diameter from about four times that of a human hair down to fibers which are invisible to the unaided eye. The beam of the balance is a quartz fiber framework some four inches in length which is suspended inside a brass housing on a horizontal fiber at right angles to the plane of the beam. From each end of the beam there hangs a fiber to which is attached a quartz frame holding a weighing pan of thin platinum foil. Objects to be weighed are placed on the foil. The addition of a weight to one side of the balance causes the beam to be depressed on that side. The beam is restored to its initial position by twisting in the opposite direction on the fiber which supports it. The torsion applied in order to return the beam to its initial position, after the addition of a weight, is measured and used to evaluate the weight added. The movement of the beam is magnified by a suitable optical arrangement, and during a weighing all parts of the balance are protected against the slightest air currents.

A pure chemical compound of plutonium, free from carrier material and all other foreign matter, was prepared by B. B. Cunningham and L. B. Werner at the Metallurgical Laboratory in Chicago on 18

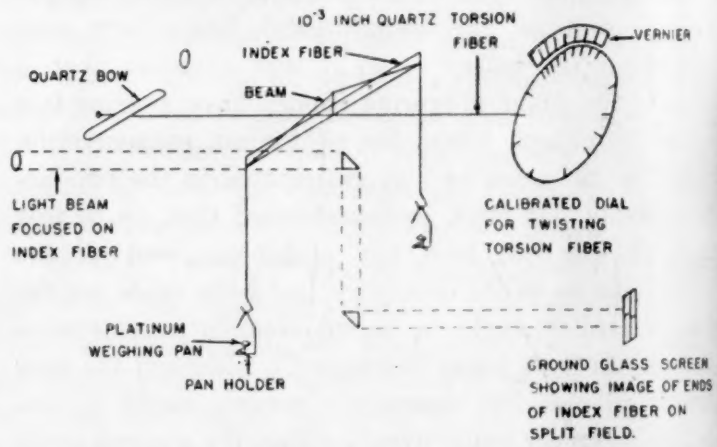
$10^{-3}$ INCH QUARTZ TORSION FIBER
VERNIER
INDEX FIBER
QUARTZ BOW
BEAM
LIGHT BEAM FOCUSED ON INDEX FIBER
CALIBRATED DIAL FOR TWISTING TORSION FIBER
PLATINUM WEIGHING PAN
PAN HOLDER
GROUND GLASS SCREEN SHOWING IMAGE OF ENDS OF INDEX FIBER ON SPLIT FIELD.

FIG. 4. Quartz fiber torsion microbalance, with a sensitivity of 0.02 μg., a weighing range of 300 μg., and a load capacity of 25 mg.

August 1942. There were available to these men for the accomplishment of this feat only a couple of micrograms of plutonium produced by the bombardment of uranium by neutrons from the Berkeley cyclotron. This memorable day will go down in scientific history to mark the first sight of a synthetic element and the first isolation of a weighable amount of an artificially produced isotope of any element.

During the summer of 1942 large amounts of uranium (hundreds of pounds) were bombarded for several months in the cyclotrons of the University of California, Berkeley, and Washington University, St. Louis. This resulted in the production of a couple of hundred micrograms of plutonium—happily, a great deal more than had been anticipated—and made it possible to extend considerably the program of ultramicrochemical investigation. In September

1942 Cunningham and Werner were able to prepare a number of compounds of pure plutonium (Fig. 5) and to determine with certainty, by means of chemical analysis, that the oxidation number of the most stable state of the element in solution is IV. The group remaining in Berkeley with W. M. Latimer, including A. C. Wahl, J. W. Hamaker, and G. E. Sheline, also contributed to this ultramicrochemical program of investigation and were able to show that the oxidation number of the highest oxidation state is VI. In addition, R. E. Connick established the existence of the III state. From this time until the end of 1943 these cyclotron bombardments were the sole source of plutonium, and over this period of time about 1,000 μg., or 1 mg. of plutonium were prepared. This material was used to maximum advantage by the ultramicrochemists to prepare compounds of plutonium and to measure properties such as solubilities and oxidation potentials. In particular, it was possible—and this was of inestimable importance—to test the separation processes which were under consideration for use at Hanford. The various parts of the complicated separation and isolation procedures were tested in the careful and crucial experiments performed by Cunningham, Werner, D. R. Miller, I. Perlman, and others. Without the possibility of these tests, I believe that it is fair to say that the process which is now in use at Hanford and which has turned out exceedingly well would not have been chosen.

FIG. 5. Twenty μg. of pure plutonium hydroxide in capillary tube (magnified about 40-fold) isolated in September 1942. The plutonium is the cloudlike mass at the bottom of the capillary "test tube."

It should be emphasized that the scale-up between the ultramicrochemical experiments to the final Hanford plant amounts to a factor of about $10^{10}$, surely the greatest scale-up factor ever attempted. In spite of these difficulties the chemical separation process at Hanford, to which crucial contributions were made by S. G. Thompson, was successful from the beginning, and its performance exceeded all expectations. High yields and decontamination factors (separation from fission activity) were achieved in the very beginning and have continued to improve with time. The huge plutonium manufacturing plant at Hanford, Washington, was built and operated by the E. I. du Pont de Nemours Company, which has done a marvelous job in making this a successful production plant.

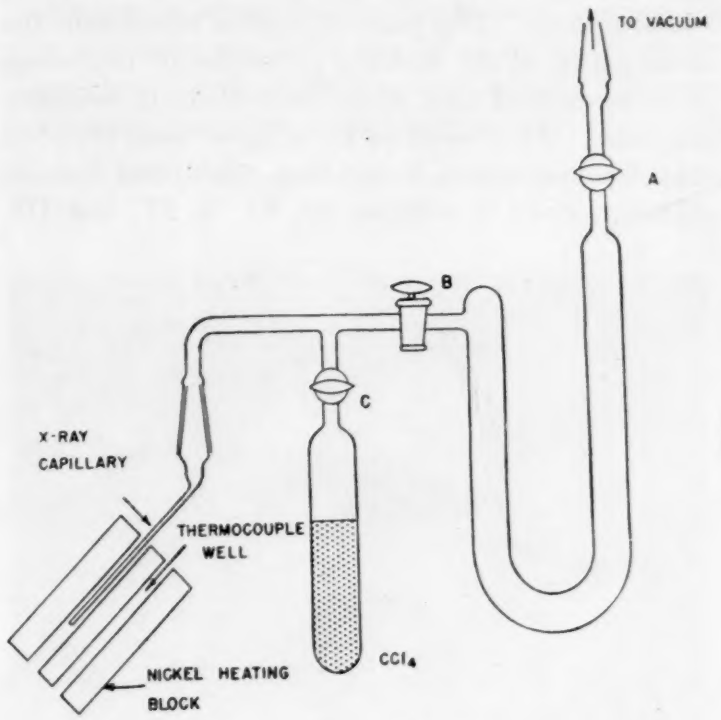


FIG. 6. Ultramicro dry chemistry apparatus.

In addition to the need for work with pure plutonium in connection with the separation process, it was necessary to determine a number of the physical and chemical properties of the dry salts of plutonium and of plutonium metal. Therefore, the investigation on the ultramicro scale had to encompass this field of investigation also. A number of compounds of plutonium were prepared by reactions involving the solid and gas phases—that is, by dry chemical reactions (Fig. 6). This work was done in collaboration with Dr. Zachariasen, of the University of Chicago staff, who was able to use his X-ray technique to identify or help identify a number of the compounds which were synthesized and, in many cases, thus to establish their chemical structure. Another feat accomplished with only microchemical amounts of plutonium was the preparation of plutonium metal and the study of some of its properties. This was done by P. L. Kirk and H. L. Baumbach and those working with them in their groups.

Later in the history of the Plutonium Project, of course, larger amounts of this element became available to the chemists as the result of successful operation of the chain-reacting units and chemical extraction plants. This made it possible to continue the investigation of the chemical properties of plutonium at an accelerated rate, using the methods of ordinary chemistry. As a result of all of these basic chemical studies of plutonium it has been established that its oxidation states in solution are VI, V, IV, and III,

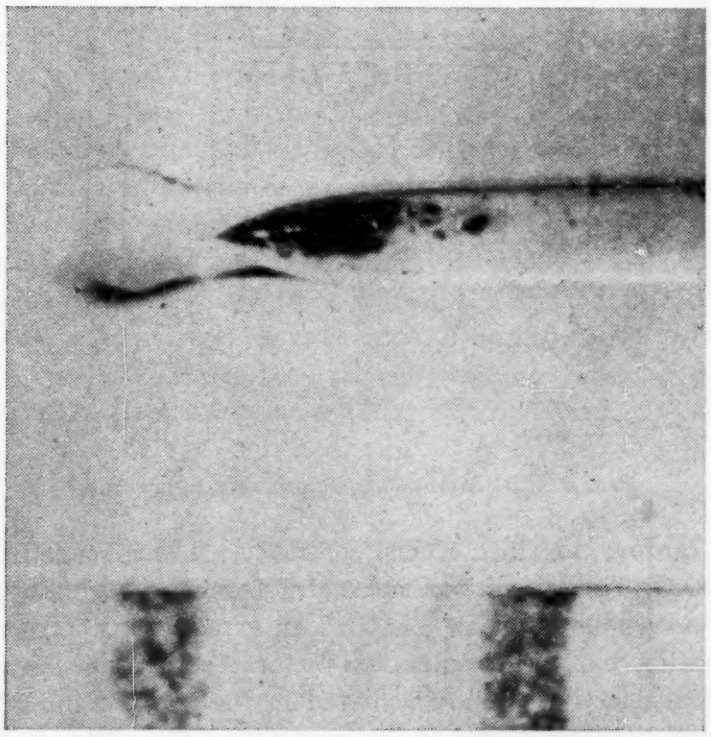

FIG. 7. Ten μg. of pure neptunium oxide at bottom of capillary tube (magnified about 40-fold) isolated in 1944. Below the sample, for purposes of comparison, is a millimeter scale.

and that there is a shift in stability toward the III state as compared to neptunium and uranium.

Nearly as interesting as the story of the first isolation of pure plutonium is the account of the first isolation of pure neptunium, the second synthetic element to be isolated in pure form. As mentioned above, the early chemistry of neptunium was limited to studies by the tracer technique using the short-lived isotope, $Np^{239}$. Fortunately, there is another isotope of neptunium, $Np^{237}$, discovered early in 1942 by A. C. Wahl and G. T. Seaborg at the University of California, which is sufficiently long-lived to make it possible to work with weighable amounts. This isotope is the decay product of the previously known seven-day beta-particle emitter, $U^{237}$, which is formed (*3, 5*) as the result of an (n,2n) reaction on $U^{238}$ and is an alpha-emitter of very long half-life, $2.25 \times 10^6$ years.

The first weighable amounts of $Np^{237}$ were produced by the bombardment of large amounts of uranium with the fast neutrons from the cyclotron. The reaction for the production of this isotope is such that the yield is considerably less than that for $Pu^{239}$, and therefore the total amounts which were available for study were even smaller than the tiny amounts of $Pu^{239}$ referred to above. Nevertheless, L. B. Magnusson and T. J. LaChapelle, at the Metallurgical Laboratory of the University of Chicago, were able during 1944 to isolate the element in the form of pure compounds (Fig. 7) and to study a number of its important chemical properties. The equipment and techniques were the same as those described above.

Just as in the case of plutonium, it was later possible to obtain larger amounts of this isotope. It is very fortunate, indeed, that the large chain-reacting units at Clinton and Hanford produce this isotope, and that by means of special chemical extraction procedures it has been possible to extract and make available for chemical studies more than 100 mg. Using this material, these same men, together with J. C. Hindman, have been able to make an intensive study of the chemical properties of neptunium, leading to the establishment of its oxidation states and the properties of a large number of its compounds. This work has shown that neptunium, like plutonium, has the oxidation states VI, V, IV, and III, with the lower oxidation states relatively more stable than those of uranium but less so than those of plutonium. S. Fried, N. R. Davidson, and A. E. Florin are responsible for a considerable amount of the investigation of the dry chemistry of this element.

Rather recently in the course of this development the next two elements, those with atomic numbers 95 and 96, were discovered. Isotopes of these elements were identified in the experiments of G. T. Seaborg, R. A. James, L. O. Morgan, and A. Ghiorso, at the Metallurgical Laboratory, who found that they are formed as the result of bombardment of uranium and plutonium with very high energy (40–44 Mev) helium ions in the Berkeley cyclotron. The bombardment of $U^{238}$ leads to the isotope of element 95 with mass 241—that is, $95^{241}$; and the bombardment of $Pu^{239}$ leads to two isotopes of element 96 of mass 240 and 242—that is, $96^{240}$ and $96^{242}$ (see Fig. 9). The $95^{241}$ is the daughter of a relatively long-lived beta-emitting $Pu^{241}$, which, of course, is formed in the primary reaction of $U^{238}$ and helium ions. All three of these transplutonium isotopes are radioactive and decay with the emission of alpha-particles. This work was made possible by the vital participation and cooperation of J. G. Hamilton and his group at the University of California, who have recently rebuilt the Berkeley 60-inch cyclotron to produce the required high-energy particles, and who performed the bombardments.

Elements 95 and 96 should, of course, have names, and these investigators have proposed the following in

which these "actinide" elements (see below) are given names by analogy with the corresponding members of the "lanthanide" earths. They have suggested for element 95, with its six 5f electrons, the name "americium" (symbol, Am); thus, this element would be named after the Americas, or New World, by analogy with europium, with its six 4f electrons, which was named after Europe. For element 96, containing seven 5f electrons, they have suggested "curium" (symbol, Cm), after Pierre and Marie Curie, historical leading investigators in the field of radioactivity; this is by analogy with gadolinium, containing seven 4f electrons, which recalls Gadolin, the great investigator of the rare earths.

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LANTHANIDE SERIES | 57 La 138.92 | 58 Ce 140.13 | 59 Pr 140.92 | 60 Nd 144.27 | 61 | 62 Sm 150.43 | 63 Eu 152.0 | 64 Gd 156.9 | 65 Tb 159.2 | 66 Dy 162.46 | 67 Ho 163.5 | 68 Er 167.2 | 69 Tm 169.4 | 70 Yb 173.04 | 71 Lu 174.99 |
| ACTINIDE SERIES | 89 Ac | 90 Th 232.12 | 91 Pa 231 | 92 U 238.07 | 93 Np 237 | 94 Pu | 95 Am | 96 Cm | | | | | | | |

FIG. 8. Periodic table showing heavy elements as members of an actinide series.

The availability of these isotopes has made it possible to study the chemical properties of americium and curium. Deductions from work on the tracer scale with these isotopes lead to the conclusion that the III oxidation state is the most stable and by far the most important state for these elements in aqueous solution. In fact, in the case of curium the evidence indicates that the III state is the only one that exists in aqueous solution.

I should like to make a few general remarks on the chemical properties of the whole group of heavy elements and to point out what bearing these properties have on the question of the electron structure of these elements. I have pointed out the tendency toward stabilization of the lower oxidation states, in particular the III state, as we go toward higher atomic numbers. Although the atomic structure of these elements cannot be treated in any detail in this discussion, I do want to say that the evidence strongly indicates that we are dealing here with a transition series of elements in which the 5f electron shell is being filled in a manner similar to the filling of the 4f electron shell in the well-known rare earth series. Apparently this new transition series begins with actinium in the same sense that the rare earth series begins with lanthanum, and, although the first elements in the heavy series exhibit the property of undergoing oxidation to higher states up to a maximum oxidation state of VI, the tendency in the later members of the series is to have a stable lower oxidation state, such as the III state. The most important criterion for arranging the heavy elements in this series (Fig. 8) is the probable presence of seven 5f electrons (analogous to the stable gadolinium structure) in tripositive curium (element 96), rather than the presence of the first 5f electron in thorium. In fact, there might not be any such electrons in thorium with, for example, their first appearance in protactinium (two 5f electrons) or in uranium (three 5f electrons); and, of course, it is recognized that the 5f and 6d shells of the elements in this region lie so close together that the energy necessary for the shift from one shell to the other may in some cases be within the range of chemical binding energies. Previous to the discovery of the

transuranium elements, it was almost the universal attitude that a simple filling of the 6d shell of electrons was taking place (*i.e.* in the elements of atomic numbers 89–92), and practically all of the standard works and textbooks on chemistry and physics adopted this view. It was possible to come definitely to this other view only as a result of the study of the transuranium elements. However, it should be pointed out that a number of people have previously made the suggestion that the 5f electron shell begins to be filled in this region, just before or after uranium. It is beyond the scope of the present discussion to review these suggestions.

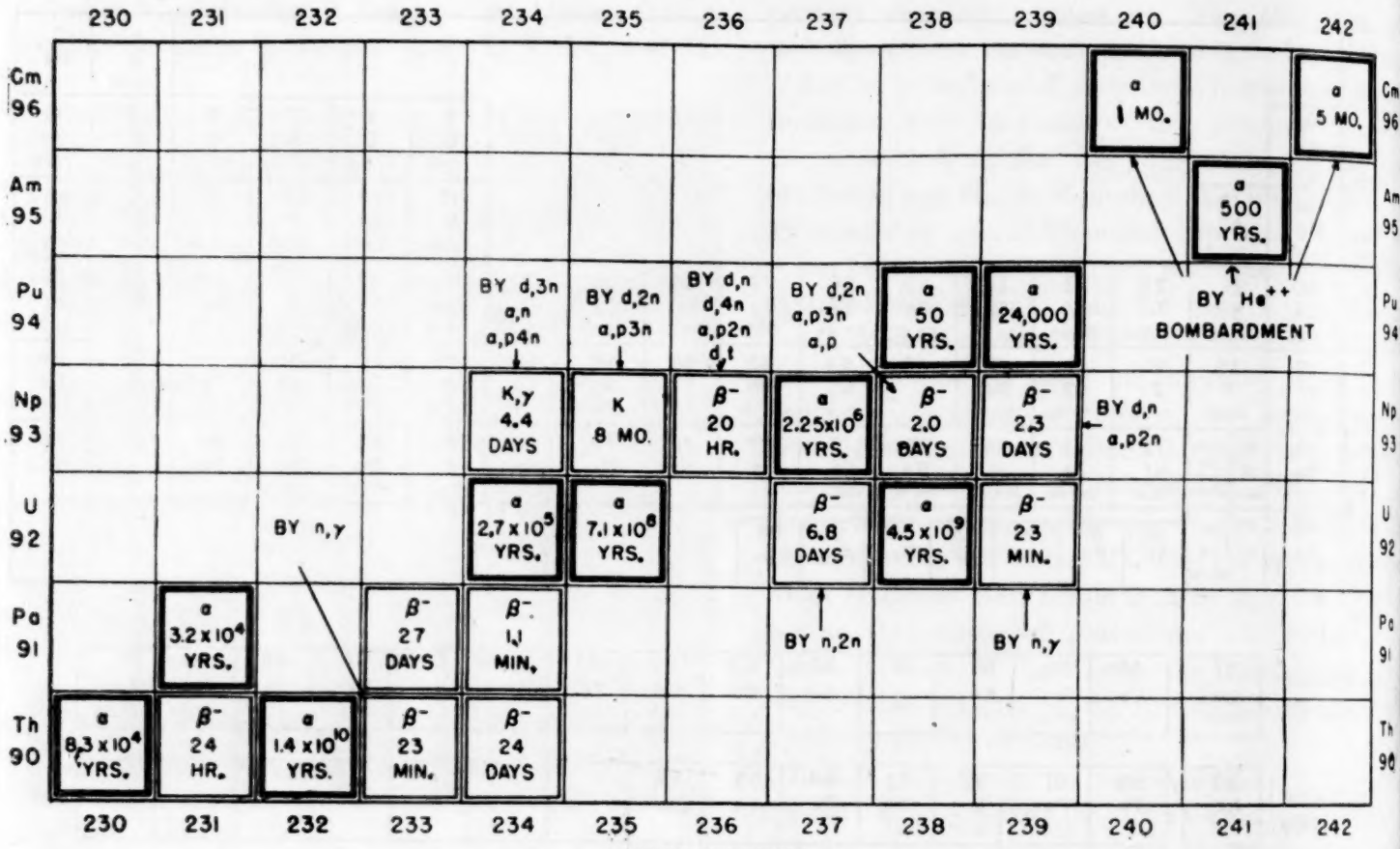


FIG. 9. Chart showing some new heavy isotopes.

A number of new isotopes in addition to those already mentioned have been produced in the region of the heavy elements. For the production of these isotopes, deuterons of energy 22 Mev and helium ions of energy 44 Mev in the recently rebuilt Berkeley 60-inch cyclotron were used. With particles of such high energy it has been possible to observe a number of interesting reactions, as exemplified by the reactions d,4n and d,p3n with deuterons and α,6n and α,p5n with helium ions. The chart in Fig. 9 shows some of the new isotopes which have been produced and the reactions by which they were produced, and, in particular, isotopes of neptunium (element 93). Most of the observations concerning these new isotopes of neptunium are due to R. A. James, A. E. Florin, H. H. Hopkins, M. H. Studier, E. Hyde, and A. Ghiorso.

The isotope $Np^{237}$, which emits alpha-particles with a half-life of $2.25 \times 10^6$ years, is of particular interest because it has been available in weighable amounts for experiments, as mentioned above. Thus, it has been possible to measure its cross-section for the absorption of thermal (cadmium-absorbable) neutrons, *i.e.* its cross-section for the reaction $Np^{237}$ (n,γ) $Np^{238}$. The value obtained by A. H. Jaffey and L. B. Magnusson is 200 barns (one barn = $10^{-24}$ cm.$^2$), but this value is of a preliminary nature and probably is only correct within a factor of about 1.5. It has also been possible to test this isotope for thermal neutron fissionability, and the very interesting result has been obtained by A. Ghiorso and L. B. Magnusson that the isotope does undergo fission with thermal neutrons with a cross-section of about 0.02 barn.

The work on the deuteron and helium ion bombardments of the heavy elements was again made possible by the vital cooperation and participation of J. G. Hamilton and his group, who rebuilt the 60-inch cyclotron for this purpose and performed the bombardments.

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# Obituary

## Carl Louis August Schmidt
### 1885-1946

Carl Louis August Schmidt, professor of biochemistry and chairman of the Division of Biochemistry of the University of California for 22 years, died in Berkeley on 23 February 1946.

Dr. Schmidt was born on 7 March 1885 in Brown County, South Dakota, the only child of Gustav and Friderike Schmidt. By the time of his graduation with the B.S. degree from the University of California, in 1908, he had already published four articles and had been elected to full membership in Sigma Xi.

Between 1909 and 1912 he worked under the direction of Prof. A. E. Taylor, of the Referee Board of the U. S. Department of Agriculture, on the possible toxicity of sulfite, aluminum, and copper in food preservation.

Returning to the University of California in 1912, he spent a term in the study of bacteriology, and in 1913 he was appointed chemist, bacteriologist, and food inspector for the City of Berkeley, where he assisted in organizing the municipal laboratory.

On 11 April 1914 he married Esther May Skolfield, a graduate of Stanford and bacteriologist at the State Board of Health in Berkeley. For a number of years they worked and published jointly on problems of bacteriology and immunology.

Again returning to the University on a research grant from the Hooper Foundation for Medical Research, he completed the requirements for the Ph.D. degree, which he was awarded in 1916. The thesis problem, carried out under the guidance of Profs. Gay and Robertson, was concerned with a study of the immunological properties of proteins.

After serving for two years as research assistant under Prof. Gay, he was appointed to an assistant professorship in the Department of Biochemistry and Pharmacology. In 1921 he was advanced to the rank of associate professor, and in 1924 he became professor and chairman of the Department of Biochemistry, a post which he held with distinction until the time of his death.

His administrative ability and scholarly attainment brought him many responsibilities and honors inside and outside the University. Between 1937 and 1944 he held the post of dean of the College of Pharmacy. In 1938 he served for a brief period as acting dean of the Medical School. He was also a member of the Advisory Board of the College of Dentistry and of numerous University committees, and had an important voice in determining University policy. He was elected a member of the Committee on Revision of the *United States Pharmacopoeia* in 1940 and was a member of the National Committee on Aviation Medicine during the period of the war.

Dr. Schmidt served as consulting biochemist for the University of California and Southern Pacific Hospitals, and Frederick Stearns and Company, and as a collaborator of the Western Regional Laboratory of the U. S. Department of Agriculture. He was president of Annual Reviews, Inc., between 1936 and 1946 and served on the editorial committee of *Annual Reviews of Biochemistry*. At various times he was secretary and president of the Pacific Coast Section of the Society for Experimental Biology and Medicine and during the last three years was an editor of its Proceedings. He was a member of the editorial and nominating committees of the American Society of Biological Chemists.

The research work of Dr. Schmidt was varied in character, showing the breadth of his interest. His two most lasting interests were the biochemistry of bile and the chemistry of the amino acids and proteins. In the first field he provided the explanation for the cause of the bleeding tendency in obstructive jaundice by the important discovery that the bile was a necessary vehicle for the absorption of the fat-soluble vitamins, while his work on the physical chemistry of the amino acids and proteins laid part of the foundation for the very important recent developments of their medical applications.

Dr. Schmidt did much to further biochemistry. One of his outstanding characteristics was the almost boundless energy which he devoted to any enterprise he considered worthy of his attention. He took an active part in the establishment of the important *Annual Reviews of Biochemistry* and *Physiology*. He had supreme faith in the value of research and did much to foster it in both the Medical School and the College of Pharmacy. He pioneered in developing new courses in the Division of Biochemistry. He was the moving spirit in organizing and in keeping active the Biochemical Conference, which did much to foster friendly scientific good-fellowship and interest in biochemical research on the Pacific Coast.

In addition to his many other activities, Dr. Schmidt was editor of *The chemistry of the amino acids and proteins*; with Frank W. Allen, wrote *Fundamentals of biochemistry*; and published a total of 184 journal articles.

DAVID M. GREENBERG
*University of California, Berkeley*

# Technical Papers

## Unequal Distribution of Diffusible Nonelectrolytes Across a Membrane [1]

CLARA L. DEASY

*Temple University School of Medicine, Philadelphia*

The Donnan equilibrium is a concept which explains thermodynamically the unequal distribution on the two sides of a membrane of diffusible ions in an equilibrated system containing a nondiffusible ion. By an extension of ideas first presented by Wall (*2*), who was interested in the determination of molecular weights by osmotic pressure measurements using mixed solvents, it is possible to show thermodynamically that the presence of a nondiffusible substance on one side of a membrane (or in different concentrations on the two sides) in general affects the distribution of a diffusible nonelectrolyte in the system; *i.e.* the concentrations of diffusible *nonelectrolyte* will be unequal on the two sides of the membrane.

It can readily be shown by a derivation similar to that developed by Wall that at equilibrium the following relationship holds:

$$\frac{1}{\overline{V}_L} \ln \frac{a^1_L}{a_L} = \frac{1}{\overline{V}_D} \ln \frac{a^1_D}{a_D}, \qquad (1)$$

where $\overline{V}_L$ and $\overline{V}_D$ are the partial molar volumes of liquid and of diffusible nonelectrolyte, respectively, on the side of the membrane containing nondiffusible solute, $a_L$ and $a_D$ are the activities on the side of the membrane containing nondiffusible solute, and $a^1_L$ and $a^1_D$ are the activities on the side not containing nondiffusible solute.

Since, in general, the partial molar volumes of liquid and of diffusible solute on the side of the membrane containing nondiffusible solute are not equal, then $\frac{a^1_L}{a^1_D} \neq \frac{a_L}{a_D}$.

For solutions which are very dilute or which approach ideality, concentration terms may be used in place of activities in (1).

It can also be readily shown that (1) is applicable to systems containing different concentrations of nondiffusible solute on the two sides of the membrane.

Qualitative deductions regarding the type of concentration changes to be expected in any particular system can be derived from (1). If the partial molar volume of the liquid, $\overline{V}_L$, is greater than that of the solid, $\overline{V}_D$, then $\frac{a^1_L}{a_L} > \frac{a^1_D}{a_D}$. If $\overline{V}_L$ is less than $\overline{V}_D$, then $\frac{a^1_L}{a_L} < \frac{a^1_D}{a_D}$.

[1] The author is indebted to Dr. Luke E. Steiner, who critically read the manuscript and made many helpful suggestions.

If the diffusible nonelectrolyte present in the system is a gas, and if the solutions are ideal to the extent that Raoult's law can be applied to the liquid and Henry's law to the gas, Equation (1) becomes

$$\frac{1}{\overline{V}_L} \ln \frac{x^1_L}{x_L} = \frac{1}{\overline{V}_G} \ln \frac{x^1_G}{x_G}, \qquad (2)$$

where $x_L$ and $x_G$ are the mole fractions of liquid and of gas, respectively, on the side of the membrane containing nondiffusible solute, and $x^1_L$ and $x^1_G$ are mole fractions of liquid and of gas on the other side of the membrane.

Quantitative data which show the approximate magnitude of concentration changes to be expected from the effect are calculated from (2) for several gases in aqueous systems (Table 1).

TABLE 1*

| Gas | $\overline{V}_G$ | $\frac{\overline{V}_G}{\overline{V}_L}$ | $x_N$ | $x_L$ | $\frac{x_G}{x^1_G}$ |
|---|---|---|---|---|---|
| $O_2$ | 28 | 1.6 | 0.05 | 0.95 | 0.92 |
| " | " | " | 0.10 | 0.90 | 0.84 |
| $N_2$ | 35 | 2.0 | 0.05 | 0.95 | 0.90 |
| " | " | " | 0.10 | 0.90 | 0.81 |
| $CO_2$ | 40 | 2.2 | 0.05 | 0.95 | 0.89 |
| " | " | " | 0.10 | 0.90 | 0.79 |

* For all calculations it was assumed that $\overline{V}_L = 18$ and $x^1_L = 1$.

In the calculations the partial molar volume of water in the solution was assumed to be its molar volume; the partial molar volume of the gas in the solution was assumed to be its molar volume as a liquid; all temperature effects were neglected. The mole fractions of water in both solutions were calculated neglecting the small concentration of the gas.

If the effect discussed in this paper were neglected, and if the experimentally determined partial pressures of the gas on each side of the membrane were assumed equal at equilibrium (an assumption frequently made, *1*), then the ratio $\frac{x_G}{x^1_G}$ should be 1 for all cases. If it were assumed that the concentrations $\left(\frac{\text{moles of gas}}{\text{moles of liquid}}\right)$ are the same at equilibrium on the two sides of the membrane, then the ratio should be 0.95 (if $x_N = 0.05$) and 0.90 (if $x_N = 0.10$), where $x_N$ is the mole fraction of nondiffusible solute. The actual values (Column 6) indicate that the ratio may vary from 0.79 to 0.92.

With the present lack of necessary data on biological systems, it is impossible to assess quantitatively the importance of this phenomenon in the dis-

tribution of nonelectrolytes across living membranes. However, it is suggested that the phenomenon might be of importance wherever a diffusible nonelectrolyte passes through a membrane with different concentrations of nondiffusible solute on the two sides as, for example, in the passage of oxygen and carbon dioxide through the lung membrane, of gases and of diffusible solids from the blood to the body tissues, and of gases and of diffusible solute through plant membranes, and in the formation of urine and other body fluids.

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## The Use of Cytochrome C in Combating Tissue Anoxia [1]

SAMUEL PROGER and D. DEKANEAS

*Joseph H. Pratt Diagnostic Hospital* and *Tufts College Medical School, Boston, Massachusetts*

We have been interested in attacking the problem of tissue anoxia by attempting to improve the efficiency of the tissue utilization of oxygen. In this connection it is important to recall that even under conditions of anoxia there is considerable oxygen in the venous blood. Thus, under conditions of anoxia which are barely compatible with consciousness (about 10 per cent oxygen) there may still be in the venous blood returning to the heart some 4–6 vol. per cent oxygen. Under such conditions there is therefore an available supply of oxygen which needs only to be utilized. Theoretically, respiratory enzymes might favor such utilization.

Our earlier studies (*5*) were with the group of $C_4$ dicarboxylic acid substances in the so-called Krebs cycle, particularly succinic acid. These are probably among the less important of the respiratory catalysts, but our studies with these substances served to demonstrate that one could, by means of such substances, apparently improve the tissue utilization of oxygen in the living animal under conditions of anoxia.

Among the most important of the substances which promote tissue oxidation are the cytochromes. Of these, only cytochrome C can be readily prepared (*2*). We have used beef heart as the source of cytochrome C and have found that, by reprecipitation and passage through a Seitz filter, it is apparently nontoxic. The fact that it has been demonstrated to be not only nontoxic but stable makes it clinically utilizable. Despite the fact that cytochrome C is a protein (iron porphyrin protein), it appears to be nonantigenic.

[1] This work was done with the aid of grants from Brewer and Company, Inc., and the Charlton Fund.

Certain facts make cytochrome C potentially useful. Among these is the fact that its organ content can be significantly increased by parenteral injection (*8, 9*). Also, the organs normally contain considerably more cytochrome oxidase than can be activated by the cytochrome C present (*4, 11*). Hence, if additional cytochrome C can be supplied to the organs, additional cytochrome oxidase is present for activation for the final linkage with molecular oxygen. Also, we find that the magnitude of increase of cytochrome C which can be produced in organs by parenteral injection is such as to produce *in vitro* an increase of oxygen consumption of 50–100 per cent (*9*). The final fact of importance in this connection is, as indicated above, that there is even under conditions of anoxia considerable unused oxygen in the venous blood returning to the heart, so that if the tissue uptake of oxygen can be increased, there is an available supply of oxygen.

On the basis of these considerations it might have been anticipated that conditions associated with anoxia *in vivo* might be benefited by the injection of cytochrome C. This seems, in fact, to be the case, as indicated by the following observations.

The easily hydrolyzable phosphorus fraction, particularly adenylpyrophosphate, is thought to play an important role in the tissue transfer of energy (*3*). This compound continuously donates phosphoric acid radical to other metabolites and hence requires continuous resynthesis. The continual release of this so-called "phosphate-bond" energy is only possible through a continual supply of the energy released by the cell oxidations which are catalyzed by the cytochrome-cytochrome oxidase system and which serve to resynthesize the adenylpyrophosphates. We have demonstrated in rats that the organ content of these phosphates is markedly diminished under conditions of severe anoxia (*10*). When, however, some additional cytochrome C has been supplied to the rats beforehand, the anoxia produces little or no change in the organ content of the phosphates concerned (*10*). If such important biochemical effects of anoxia can be largely prevented by cytochrome C, it is not unlikely that other effects, in addition to those associated with phosphorylation, can also be favorably influenced.

The effects of anoxia on the living heart can be easily studied by means of the electrocardiogram. We have found that such effects on the electrocardiogram as can be produced by moderately severe anoxia (10 per cent oxygen and 90 per cent nitrogen) can be regularly prevented by the previous intravenous injection of cytochrome C (*6*). Also, those patients who experienced subjective distress with such anoxia were free from the distress under the anoxia when they had been injected previously.

These facts naturally lead to some observations on

patients with angina pectoris and coronary thrombosis. Our limited observations thus far have indicated that with the dosages employed and in short, acute experiments, cytochrome C seems to have a moderately beneficial effect in angina pectoris and no immediate effect in acute myocardial infarction (*6*). The latter may well be due to the fact that the total occlusion of the vessel makes it impossible for the cytochrome to reach the infarcted area.

Studies of certain cerebral functions have demonstrated that cytochrome C is effective in preventing some of the consequences of anoxia on the brain (*6*). The electroencephalographic changes produced by anoxia (varying from 10 to 12 per cent oxygen) can be largely prevented by cytochrome. By injection of cytochrome C the impairment of visual discrimination induced by anoxia can be entirely overcome within about 5 minutes, and such a complex cerebral function as code transliteration can be strikingly influenced, in that the slowing in time required to decode certain standard material under conditions of low oxygen tension (pressure chamber) can be quickly and entirely overcome by the cytochrome C (*6*).

Anoxia may be considered an important factor in shock, and it may even be the chief factor leading to those chemical changes which probably result in producing the state of irreversibility in hemorrhagic shock. These considerations led us to study the influence of injected cytochrome C in shock. In traumatic (tourniquet) shock in rabbits the cytochrome seemed to have no effect. In hemorrhagic shock in dogs, however, the fatal irreversible state which usually followed the experimental conditions was prevented in 9 of 14 dogs when a large dose of cytochrome C was injected a few hours after the hemorrhage (*7*). These experiments were done under the same conditions, in the same laboratory, and by the same workers who had previously demonstrated that, despite employing several theoretically desirable treatments, 107 of 108 dogs died of "irreversible" shock (*1*).

There seems to be a peculiar reciprocal relationship between the organ and blood content of cytochrome C after injection (*9*). Normally there is no cytochrome C in the circulating blood. After injection (intramuscularly, intraperitoneally, or intravenously) there is a considerable amount in the blood as well as an increase in the organ content. When anoxia is induced, the level of cytochrome C in the blood declines sharply, while in the organs it simultaneously increases. When the anoxia is discontinued, however, the organ content decreases and the blood level rises. It is as though the blood stream served as a reservoir from which the organs take up additional cytochrome C when they need it and to which the organs release the cytochrome C when it is no longer needed. We have used this phenomenon as a guide to dosage, which is made sufficiently large so that under conditions of anoxia there is still some cytochrome C in the blood. (This can be quickly and easily determined qualitatively by noting the presence in the serum of a pinkish color not unlike that of hemolyzed blood.) Under these circumstances it is assumed that there is a maximum supply in the organs where it is needed—that is, there is an "overflow." If, under the conditions of anoxia, there is no cytochrome C in the blood, one cannot be certain that the organ content of cytochrome C has been raised to an adequate level for effectiveness. Employing such a guide, we find that the effective dose may vary from 50 mg. for the purpose of preventing anoxia changes in the electrocardiogram in human beings to 350 mg. to prevent irreversibility in hemorrhagic shock in dogs.

The fate of the injected cytochrome C in the body is not clear. It is not recoverable in the urine (except following excessive doses), and it is assumed that it is broken down before excretion. If such is the case, the breakdown rate is fairly uniform. For, whereas 50 mg. injected intravenously will gradually disappear from the blood stream in 24–48 hours (man and dog), 350 mg. injected intravenously will result in gradually diminishing blood levels over a period of 5–6 days. It is conceivable, therefore, that if further studies continue to show cytochrome C to be nontoxic in unlimited doses, a single large injection may be used to serve as a supply for several days or longer.

Obviously, it is desirable to explore the possible usefulness of such a substance as cytochrome C in all conditions in which anoxia, acute or chronic, is thought to play a role. Such conditions, in which we have already made some preliminary observations, may be as diverse as Raynaud's disease, pulmonary emphysema, hemorrhagic shock, certain cerebral dysfunctions, etc. Among the more intriguing possibilities for future study are those degenerative diseases associated with arteriosclerosis in which mild chronic anoxia may be a significant factor.

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# News and Notes

## About People

*Leo Szilard* was appointed professor of biophysics and of social sciences, University of Chicago. He will spend one-half of his time in the University's new Institute for Radiobiology and Biophysics, and the other half with the Division of Social Sciences.

Dr. Szilard worked with Fermi in the early days of chain reaction at Columbia and at Chicago, where the first chain reaction was demonstrated 2 December 1942. Born in Budapest in 1898, Dr. Szilard received his Ph.D. from the University of Berlin in 1922 and served on its faculty from 1925 to 1933. He became an American citizen in 1943.

*Frederick Wyatt,* chief psychologist at McLean Hospital, Waverley, Massachusetts, has been appointed research associate in the Department of Social Relations, Harvard University. He will supervise a training and orientation course for students of clinical psychology at McLean Hospital.

*O. H. Maughan,* formerly director of research, Farm Credit Administration, Spokane, Washington, assumed his new duties as professor and head of the Department of Agricultural Economics, College of Agriculture, and chairman of the Division of Agricultural Economics, Agricultural Experiment Stations, State College of Washington, Pullman, on 1 June.

*W. C. Gorham,* lecturer at Union College, Schenectady, New York, has been appointed tutor at St. John's College, Annapolis, Maryland, where he will be in charge of the biological laboratories.

*E. W. Thompson,* who has been manager of the Louisville neoprene synthetic rubber plant, which the Du Pont Company built and is operating for the Government, has been appointed production manager of the Rubber Chemicals Division of the Company. He assumed his new position on 1 October and will be succeeded as manager by E. F. Ridlon, who has been assistant manager of the Louisville plant.

*Pierce Brodkorb* has been appointed assistant professor of biology at the University of Florida.

*Wolcott B. Dunham* has resigned from the Squibb Institute for Medical Research to become doctor, senior grade, for assignment as research biologist at the Kennedy Veterans Administration Hospital, Memphis, Tennessee.

*Hugh G. Gauch,* formerly assistant professor of plant physiology at Michigan State College, became associate professor of plant physiology in the Department of Botany, University of Maryland, on 1 September.

*Maj. George W. Hunter, III,* formerly on the faculty at Wesleyan University, is now stationed at the Army Medical School, Washington, D. C., where he is serving as chief of the Division of Parasitology. He recently received his commission in the Regular Army as a major in the Pharmacy Corps. In 1945 Maj. Hunter served as Executive Officer with the Commission on Schistosomiasis which went to the Philippines that spring. He is the recipient of both the Bronze Star and the Army Commendation ribbon.

*C. M. Louttit,* recently of The Ohio State University, has been appointed dean of Sampson College, Sampson, New York, one of the three emergency colleges for veterans created by New York State this year.

*William B. Herms,* for 38 years a member of the faculty of the University of California, retired on 22 September. Dr. Herms was head of the Division of Entomology and Parasitology for 23 years. He is a past-president of the Entomological Society of America and of the American Association of Economic Entomology.

*A. Williams Postel* has recently resigned from the Department of Earth Sciences, University of Pennsylvania, to join the staff of the Division of Metalliferous Geology, U. S. Geological Survey.

*W. M. Firor,* Johns Hopkins Hospital, in continuing to direct research in cellular physiology being supported by funds provided by Sharp and Dohme, Inc. Special emphasis is being given to the alteration of normal into malignant cells in tissue culture.

*Delos D. Wickens,* formerly at the University of Wisconsin, has been appointed associate professor of psychology at The Ohio State University.

*Donald T. Ries,* formerly naturalist at the Starved Rock State Park, Illinois, and recently released from active duty with the Sanitary Corps, AUS, has been appointed assistant professor of biology, Illinois State Normal University, Normal, Illinois.

*W. R. Horney,* who recently completed work on his doctorate at Yale University, has been added to the staff of the Department of Geology, University of Nebraska.

*Donald B. MacMillan* has returned from his 24th Arctic Expedition, bringing back some 60 specimens of birds for the Colorado Museum of Natural History. He is now planning his 25th trip, a cruise with geologists, botanists, anthropologists, and ornithologists along the Labrador, Baffin Land, and Greenland coasts

up to within 11° of the Pole. His veteran schooner, Bowdoin, which has now covered 125,000 miles in arctic work, will sail from Boothbay Harbor, Maine, on 20 June 1947, returning on or about 10 September.

*Bernard S. Meyer,* recently named editor-in-chief of the *American Journal of Botany,* succeeded E. N. Transeau on 31 August as chairman of the Department of Botany in The Ohio State University's College of Agriculture.

*W. Albert Strong,* formerly of the University of Illinois, has recently joined the Antibiotic Division of the Research Laboratories, The Wm. S. Merrell Company, Cincinnati, Ohio.

*William W. Greulich,* professor of anatomy at Stanford University and director of the Brush Foundation, is visiting the universities and medical schools in Australia and New Zealand during the autumn quarter. Dr. Greulich, who is accompanied by Mrs. Gruelich, plans to return to this country in December.

*J. Russell Bright* has been made associate professor of chemistry in the College of Liberal Arts, Wayne University, Detroit, where he is to be responsible for the development of general chemistry. Dr. Bright formerly was associate director of control at Gelatin Products Corporation, Detroit.

*Gilbeart H. Collings, Jr.,* of the medical staff of the Bethlehem Steel Corporation, Baltimore, has been appointed chief of the Industrial Hygiene Staff of the Tennessee Valley Authority. He will be located at Wilson Dam, Alabama.

## Announcements

*Industrial research laboratories of the United States* (8th ed.) is now ready for distribution by the National Research Council. This directory has been compiled by means of an extensive questionnaire survey of several thousand industrial organizations and includes for each reporting company: name of the president, location of the laboratories and of the laboratories of subsidiary companies, names of key men in research, a brief description of research activities, information on scientific periodicals issued and the size of the library, and a statement concerning the grants for research, fellowships, and scholarships maintained at educational or other institutions. The directory is indexed with respect to personnel, geographical location, and research activities. As a new feature, the present edition contains an appendix listing 292 universities and colleges offering research service to industry, with the name of the person to whom correspondence should be addressed.

Comparison of the present volume, for which data were obtained between August 1945 and January 1946, with the 1940 edition shows that professional personnel increased 48.5 per cent, to 54,321; technical personnel, not included in the professional group, increased 110.8 per cent, to 34,563; and administrative, clerical, and maintenance personnel increased 161.3 per cent, to 44,631. The ratio of the three groups is now approximately 11:7:9 instead of the former 2:1:1. Each professional classification showed growth. The biologist and bacteriologist group showed the greatest increase, 69.4 per cent; chemists increased 34.4 per cent; engineers, 37.8 per cent; physicists, 31.0 per cent; and metallurgists, 20.9 per cent.

This directory may be obtained from the Publications Office, National Research Council, 2101 Constitution Avenue, Washington 25, D. C., at $5.00 per copy.

*A Procter and Gamble fellowship in chemistry* has been established at the University of Pittsburgh for graduate study in the field of fat chemistry.

*The Life Insurance Medical Research Fund awards* for the current year were announced by the Board of Directors on 17 September. The awards, including nine additional fellowships and three grants-in-aid, are all in connection with research on fundamental problems of cardiovascular disease or function.

Postgraduate research fellowships were awarded as follows: Harwell G. Davis, II, Birmingham, Alabama, to work at the Medical College of Alabama; Charles V. Dowling, Jamaica, New York, to work at Western Reserve University; Jerome Gross, New York City, to work at Massachusetts Institute of Technology; Harper K. Hellems, Lewisburg, West Virginia, to work at Peter Bent Brigham Hospital, Boston; Jack J. Lewis, Los Angeles, to work at Stanford University; Harold Mankin, Bronx, New York, to work at Columbia University College of Physicians and Surgeons; George E. Murphy, Kansas City, Missouri, to work at the Rockefeller Institute for Medical Research; and Hugh Grant Skinner, New Toronto, Ontario, to work at the University of Toronto.

Student research fellowships were awarded to: Thomas C. Hall, Boston, Massachusetts, to work at Harvard Medical School; Marie Louise Nieft, Chicago, to work at the University of Southern California Medical School; and Murray Saffran, Montreal, to work at McGill University.

The grants-in-aid, valued at $633,591 and some of which extend over a period of two or three years, were awarded as follows: Carnegie Institution of Washington, for support of research under the supervision of George W. Corner; McGill University of Montreal, for support of research under the supervision of David W. MacKenzie; and New York University, for support of research under the supervision of Homer W. Smith.

Applications for postgraduate research fellowships for 1947 should be made before 1 January 1947 to the Scientific Director, Life Insurance Medical Research Fund, New York Academy of Medicine Building, 2 East 103rd Street, New York 29, New York. Applications for grants-in-aid of medical research for 1947 will be accepted until 31 January 1947. Nominations for student research fellowships in 1947 (which must be made by faculty members) should not be made until later in the academic year but must be received by 15 April 1947. Further information may be secured from the Scientific Director.

*The Department of Mathematics, The Ohio State University,* has announced several personnel changes for the fall quarter. Tibor Rado has been named chairman of the Department to succeed J. L. Synge, who has become chairman of the Department of Applied Mathematics, Carnegie Institute of Technology. Two new appointments to the staff are Marshall Hall, formerly on the staff at Yale University, as an associate professor, and Howard H. Alden, formerly of the University of Wyoming, as assistant professor. Robert G. Helsel and Earl J. Mickle have been made assistant professors. Grace M. Bareis has retired from the staff after 30 years in the Department.

*The October issue of The Journal of the History of Medicine* is devoted entirely to the history of anesthesia and is called the Anesthesia Centennial Number. Josiah Charles Trent's "Surgical Anesthesia, 1846–1946" serves as an introduction to the entire issue, while the paper, "Mesmerism and Surgery: A Strange Chapter in the History of Anesthesia," by George Rosen, throws new light on this long-neglected chapter in medical history. Copies may be obtained from the publisher, Henry Schuman, Inc., 20 East 70th Street, New York City 21, for $2.50.

*The Department of Chemistry, University of California,* Berkeley, has announced the following staff changes. Glenn Seaborg has returned to the Department from the Metallurgical Laboratory in Chicago to resume his position as professor of chemistry. He was accompanied by some 20 men to participate in the research of the Radiation Laboratory. I. Perlman and B. B. Cunningham, of this group, have been made associate and assistant professors of chemistry, respectively, in the Radiation Laboratory. Philip W. Schutz, of Columbia University, has joined the Department as professor of chemical engineering to direct the curriculum in this subject. He will be assisted by two new instructors, Charles R. Wilke and LeRoy A. Bromley. The staff has been increased by 5 additional assistant professors: George Jura, University of Chicago; Richard E. Powell, Princeton University; and Robert E. Connick, Leo Brewer, and Spofford G. English, all of whom have been associated with the Manhattan Engineering District. New instructors in the Department are: Bruno H. Zimm, Jack W. Petersen, Henry Rapoport, and Estella Katzenellenbogen. Postdoctorate fellows in the Department are: Borge Bak, Marshall W. Cronyn, and Robert L. Scott.

*The Cutter Lecture on Preventive Medicine* will be delivered this year by Sir Lionel Whitby, Regius professor of physics, University of Cambridge, England, on 6 November at the Harvard Medical School. The lecture will be given at 5:00 P.M. in Amphitheater D. Sir Whitby's subject will be "The Hematological Effects of Irradiation."

*About 600 mathematicians met at Cornell University* on 20–23 August for the 52nd summer meeting of the American Mathematical Society which was held in conjunction with meetings of the Mathematical Association of America and the Institute of Mathematical Statistics. Members of the Society made up about 400 of the total attendance. Of the 111 research papers presented at the meetings, 57 were read by the authors in person, and 54 given by title.

*Rules for the John J. Abel Prize in Pharmacology,* awarded by Eli Lilly and Company, have been announced by the American Society for Pharmacology and Experimental Therapeutics. The award, consisting of a $1,000 prize and a bronze medal, is made for the purpose of stimulating fundamental research in pharmacology in the United States and Canada by a young man or woman working in a college or university. An additional amount up to $150 is available toward traveling expenses for the recipient of the prize, which is to be presented at the spring meeting of the Society in Chicago next May. The prizes will be awarded annually for a three-year period.

To be eligible for the award, a nominee shall not have passed his 36th birthday on 30 April of the year of the award and shall have accomplished outstanding research in the field of pharmacology and experimental therapeutics. The research will not be judged in comparison with the work of more mature and experienced workers and, in judging various researches, special consideration shall be given to the independence of thought and the originality shown.

Nominations for this award should be sent to the secretary of the Society, H. B. Haag, by any member of the Society except the members of the Award Committee. Nominations must be in the hands of the secretary on or before 5 January of the year of the award. No member may send in more than one nomination. At the time of nomination the nominee must

be actively engaged in the line of research for which the award is to be made. The nomination must be accompanied by five copies of: a biographical sketch of the nominee, including date of birth; a list of his publications, if any; and the publication or manuscript for which the award is to be given.

The Award Committee consists of: Carl F. Schmidt, chairman; H. B. Van Dyke, Louis Goodman, Torald Sollman, and Carl A. Dragstedt.

## Meetings

*The American Oil Chemists' Society* expects to hold the largest meeting in its history from 30 October to 1 November at the Edgewater Beach Hotel, Chicago, with an estimated attendance of 600 and a total of 40 papers. Arrangements are in charge of George A. Crapple, Wilson and Company, Chicago. S. O. Sorenson, of the Archer-Daniels-Midland Company, Minneapolis, is president.

*The Institute of Mathematical Statistics* will hold a meeting on the mathematical aspects of "Analysis of Variance" on 1 November at Princeton University. Speakers will include: M. S. Bartlett, Cambridge University; A. Wald, Columbia University; W. G. Cochran, The University of North Carolina; and J. W. Tukey, Princeton University. The secretary-treasurer of the Institute is Paul S. Dwyer, University of Michigan.

*The New York Federation of Science Teachers Associations* will meet on 15 November at 8:00 P.M. in Roosevelt Hall of the American Museum of Natural History. There are to be three speakers: Clarke Williams, Brookhaven National Laboratory: "Atomic Energy and Technology"; Howard Curtis, College of Physicians and Surgeons, Columbia University: "Biological Aspects of Atomic Energy"; and Melba Phillips, Brooklyn College: "Atomic Energy and the Teacher."

## Elections

*The American Chemical Society* announces that Gustav Egloff, director of research of the Universal Oil Products Company, Chicago, has been elected chairman of its Petroleum Division. A. N. Schanen, of the Socony-Vacuum Oil Company's General Laboratories at Paulsboro, New Jersey, was named vice-chairman, and Cary R. Wagner, consulting chemist of Bartlesville, Oklahoma, was re-elected secretary-treasurer. Stewart S. Kurtz, Jr., former chairman of the Division, and W. E. Bradley, research supervisor, Union Oil Company, Los Angeles, were chosen as members of the Executive Committee of the Division which, with 1,300 members, is the largest of the Society's 18 professional Divisions.

*George W. Vinal,* chief of the Electrochemistry Section, National Bureau of Standards, has been elected president of the Weston Cell Committee of the International Union of Chemistry. The Committee, consisting of scientists from the principal nations of the world, is engaged in the scientific development and perfection of the Weston Cell as an international standard of measurement. The Committee met in July 1946 for the first time since the beginning of the war and is scheduled to meet next in July 1947 in London.

## Recent Deaths

*W. Carl Rufus,* 70, professor emeritus of astronomy, University of Michigan, died on 21 September.

*R. Max Goepp, Jr.,* 39, director of organic research, Atlas Powder Company, was killed in a plane crash in Newfoundland on 3 October.

*Charles Butts,* 83, geologist, died on 4 October. Dr. Butts retired from the U. S. Geological Survey in 1933, having served as paleontologist from 1909 to 1912 and then as geologist until his retirement.

*Henry Metcalf Hobart,* 77, a retired consulting engineer of the General Electric Company, died on 11 October. Mr. Hobart, former vice-president of the American Institute of Electrical Engineers, developed mercury rectifiers and was an authority on arc welding, design of dynamoelectric machinery, insulation and standardization.

## Geography at Japanese Imperial Universities

Of the five imperial universities in Japan, only two possess Departments of Geography—Kyoto and Tokyo. Each is a small department with one full professor, one assistant professor, one lecturer, and one assistant. Geography is also taught at the teachers' colleges (bunri-daigaku), which are likewise under government supervision. Only a few of the geographers have been educated overseas, mainly at the Sorbonne, but several have traveled abroad and attended international geological and geographical meetings. Nevertheless, they speak some English, are able to understand more, and read the language very well. This information was obtained by the undersigned while on naval duty in Japan late in 1945.

At Kyoto Dr. Sameshige Komaki is professor and head of the department, or Institute of Geography as it is called. His doctoral dissertation was written

on the shoreline physiography of Japan. Dr. Taro Tsujimura, reputed to be the country's leading geographer, has a similar position at Tokyo.

Courses given at Kyoto include physiography, climatology, oceanography, political geography, human geography of islands, history of geography, and occasionally regional geography. The Tokyo department offers courses in geomorphology, climatology, soils, cartography, cultural geography, and the regional geography of Asia. Regional geography of areas other than Japan and the Far East generally has been neglected both in teaching and in research. When I commented on this fact, Prof. Tsujimura sadly replied: "That was our great mistake."

The Japanese university course requires 3 years and normally follows 14 years instruction in primary, middle, and higher schools. The Tokyo Institute of Geography had a total of 20 geography majors and Kyoto had 13, but the numbers of students were reported to vary considerably from year to year. A large majority of the students are preparing to teach in the secondary schools and colleges, but some have gone into research organizations with the South Manchurian Railway, the Institute of Oriental Culture, and the Home Ministry, which has been engaged in land-planning projects. Dr. Komaki pointed out that the military and naval services did not recognize the value of geographic training and that almost all the younger geographers went into the services as regular officers. A major exception was the Institute of Oriental Culture, which specialized in political geography and was connected with the military during the war.

The principal geographical publication is *The Geographical Review of Japan* (*Tirigaku Hyōron*), which is the organ of the Association of Japanese Geographers (membership, 270) and is published monthly. It is well illustrated with maps and photographs, and each article is abstracted in English. The Tokyo Institute takes the leading part in editing and publishing this journal. The Kyoto Institute, up through 1943, published an annual volume, *Papers in geography* (*Chiri-Ronso*), containing approximately a dozen articles on various geographical fields. This publication was sent on an exchange basis to the American Geographical Society, the National Geographic Society, and the University of Michigan. A so-called popular geographic monthly in Japan is *Chiri-gaku*, but its circulation is only about 5,000.

In the past, geographical instruction and research in Japan have been circumscribed to a high degree by the government, as was true of most other academic fields. During the war years no foreign publications were received or contacts made. Last winter the universities were closed because of the lack of any coal for heating. Despite these difficulties, research is continuing, and several geographers showed me maps of population and economic factors on which they were working. The excellence of their cartography made one wish that American geographers could used a brush and water colors in similar fashion.—*Robert C. Klove* (Washington University, St. Louis).

# *In the Laboratory*

## An Improved Helmet for Breathing Oxygen or Other Gases[1]

J. E. Duncan, Lt., USN
*Naval Medical Research Institute, Bethesda, Maryland*

The value of a helmet rather than a mask for inhalation of a variety of gas mixtures has long been recognized. Masks leak frequently and become uncomfortable on long wear, chiefly because of difficulty in fitting the complex curves about the nose and eyes. In physiological experiments where accurate measurements are made, an airtight fit is essential and, if pressure is to be used within the unit, a helmet is highly desirable for the same reason.

A number of helmets for this purpose have been designed during the past seven or eight years at the Experimental Diving Unit, Navy Yard, Washington, D. C., two of which were fairly successful. Several defects still remained, chief among which was fogging of the vision plate. In order to remedy these defects, the present apparatus was developed.

The construction of the hood is very simple (Figs. 1, 2). It consists of a wire frame (A), covered with canvas to form the background on which the rubber cover (B) is cemented. A removable, transparent, oval face plate (C) is held in place by four ¼-inch 20-thread wing nuts and studs (D). A sponge-rubber pillow (E) for a head rest is built in for use in the supine position but also helps to support the helmet vertically in the upright position. In the upright position, the lower flange rests comfortably on the shoulders and also keeps the helmet in position. An

[1] The material in this article should be construed only as the personal opinion of the writer and not as representing the opinions of the Navy Department officially.

adjustable exhaust valve (F) and a rubber collar (G) are attached. The inlet channels (H) inside the hood are so constructed that they direct the incoming air on the face plate. The rubber collar is made of one-inch sponge and has a two-inch flange which can be fitted by folding it either in or out. The size of the opening is chosen to fit the average neck. The exhaust valve is adjustable from 0 to 3 PSI.

The construction of the inlet channels is perhaps the greatest single improvement. Their arrangement has regularly succeeded in overcoming the fogging of the face plate, which has been so troublesome in older models with flows of oxygen of 12 liters per minute and lower.

The helmet is easy to operate. The inlet opening is

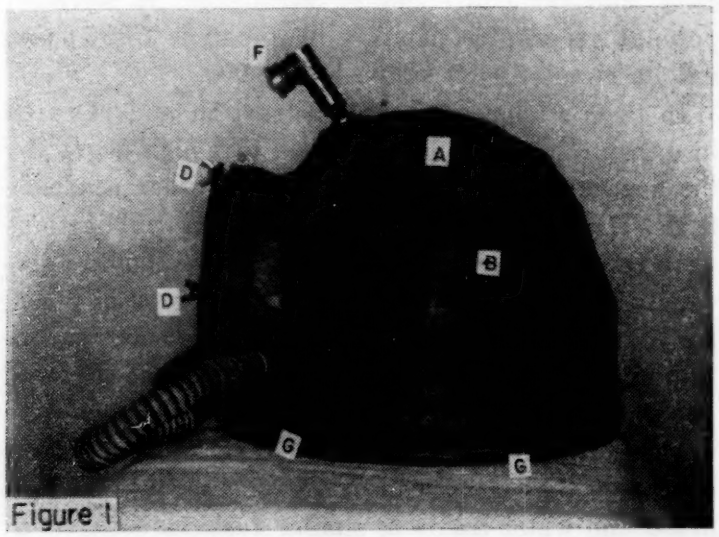


Figure 1

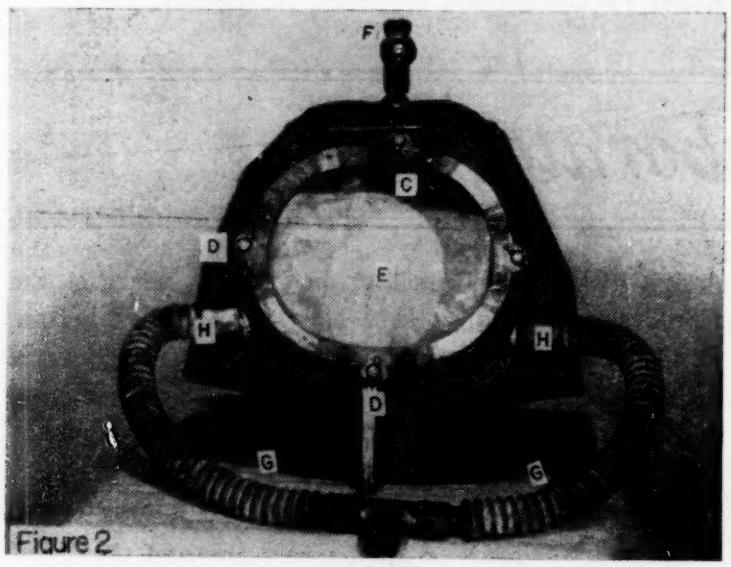


Figure 2

connected to an oxygen cylinder through a standard reducing and flow regulator. The hood operates at a constant positive pressure of 3 mm. mercury, which can be altered if desired by the adjustable exhaust valve. The helmet is placed on the subject's head by stretching the rubber collar over the head and allowing it to come back into place about the neck. This operation is the only difficult one, in that it requires two men to help the subject into the helmet easily. Communication can be maintained with the subject by ordinary speech at distances not greater than three or four feet.

Tests were conducted to ascertain the degree of wearing comfort and the gas concentrations in the helmet over long periods. The test periods were of seven to eight hours in duration. After the helmet was adjusted, the subject was placed on a cot and the flow of oxygen started. There was no discomfort other than restlessness attendant upon confinement for a long period of time. It was found that an atmosphere of practically pure oxygen could be maintained with flows as low as 10 liters per minute. In one experiment careful records of temperature of air inside

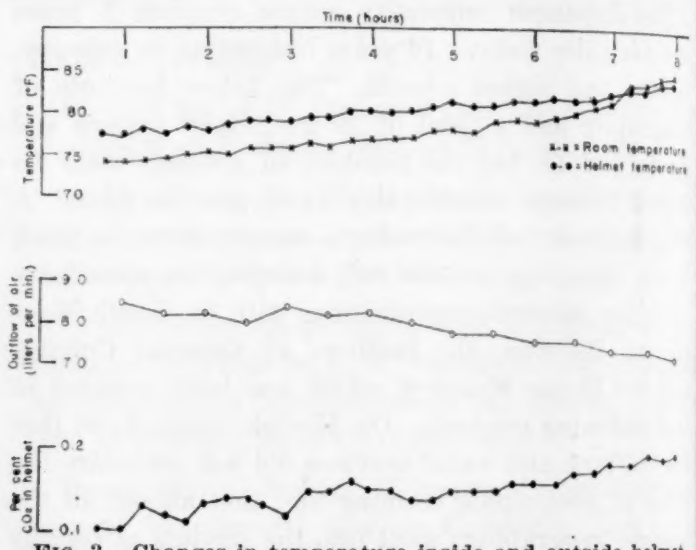


FIG. 3. Changes in temperature inside and outside helmet. Rate of outflow of air and $CO_2$ content within helmet are plotted from a 7½-hour experiment.

and outside the helmet were made (Fig. 3). Even with a small flow of oxygen there was no heating up of the air inside the helmet.

Carbon dioxide content remained low (0.15 per cent) throughout and there was no fogging of the face plate at any time.

The apparatus was also tested for use in a recirculator system in which carbon dioxide was removed and oxygen added as it was used. The helmet functioned well under these circumstances, and there was no fogging of the face plate.

The uses of a helmet are intermediate in position between those of a mask and those of a tent. It is more economical than a chamber, and higher concentrations of gas can be maintained. It cannot be as quickly removed and replaced as a mask, but it is more economical of oxygen. Because a surer fit can be obtained and because leaks can be more readily located than with a mask, a helmet is often the equipment of choice when studies involving accurate measurements of respiration are desired. A helmet which could be shown to be leak free might even replace the time-honored mouthpiece and nose clip for metabolic studies.

# Reciprocal Sensitivities of *Staphylococcus aureus* to Streptomycin, Streptothricin, and Penicillin

MARGUERITE SULLIVAN, GRANT L. STAHLY, and JORGEN M. BIRKELAND

*Department of Bacteriology, The Ohio State University*

WM. G. MYERS

*Department of Medicine, The Ohio State University*

Some strains of *Staphylococcus aureus* are inhibited or destroyed by each of the antibiotic agents—penicillin, streptomycin, and streptothricin. It is well known that susceptible strains of *Staph. aureus* may develop fastness to penicillin under both *in vitro* and *in vivo* conditions. The studies reported below were aimed at determining reciprocal sensitivities of strains of *Staph. aureus* to each of the other two antibiotics, after developing *in vitro* resistance of a susceptible strain to streptomycin, streptothricin, and penicillin separately.

## EXPERIMENTAL METHOD

*Staph. aureus* (F.D.A. 209) and *Escherichia coli* (Waksman's assay strain) were used in this work.

The penicillin used was a commercial sodium salt. The streptomycin and streptothricin were crude extracts from *Streptomyces griseus* and *Streptomyces lavendulae* cultures, respectively, which contained 900 and 1,100 units/ml. Various dilutions of each antibiotic were prepared. One ml. of each dilution was then added to 9 ml. of nutrient agar (N-Z Case nutrient agar[1] for penicillin), and the media were poured into Petri dishes. The agar plates were streaked with a 24-hour tryptose-phosphate broth culture of *Staph. aureus* and then incubated for 24 hours at 37° C. Colonies from plates containing the highest concentration of antibiotic agent permitting growth were selected, and transfers made to tryptose-phosphate broth. After incubation, the broth culture was streaked on nutrient agar containing a higher concentration of antibiotic than previously. Transfers of colonies after incubation were again made to tryptose-phosphate broth. This procedure was repeated many times with each antibiotic agent until highly resistant strains were obtained. The parent *Staph. aureus* was transferred daily in tryptose-phosphate broth and served as a control.

Each resistant strain and the parent culture were then tested for susceptibility to each antibiotic. *E. coli* was also streaked on the plates containing streptomycin and streptothricin to determine the unitage of the preparations. The procedure followed was the agar streak method commonly used for assaying these antibiotics.

[1] Methods used by F.D.A. for assay of penicillin, revised January 1945.

## RESULTS

Strains of *Staph. aureus* obtained by the procedure outlined above were highly resistant to penicillin, streptothricin, and streptomycin. The development of maximum resistance was accomplished after 12 transfers for streptomycin, 25 transfers for streptothricin, and 32 transfers for penicillin.

The principal purpose of the investigation was to determine whether the development of resistance to one of the antibiotic agents would result in resistance to one or both of the others. An inspection of Table 1 reveals that the strain which was resistant to streptothricin was also more resistant to streptomycin than was the parent culture; however, the reverse of this was not true. With the exception noted, the development of resistance to one antibiotic agent did not result in increased resistance to either of the others.

TABLE 1

RESISTANCE OF STREPTOMYCIN-FAST, STREPTOTHRICIN-FAST, AND PENICILLIN-FAST STRAINS OF *Staph. aureus* TO:

**Streptomycin**

| Strain | Dilution, 1: 20 | 40 | 80 | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1,000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Staph. aureus* | | | | | | | | | | | | | |
| Sm R | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| St R | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| Pen R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 – | 1 |
| Parent | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 – | 1 |
| *E. coli* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 – | 1 |

**Streptothricin**

| Strain | Dilution, 1: 20 | 50 | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1,000 | 1,100 | 1,200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Staph. aureus* | | | | | | | | | | | | | | |
| St R | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Sm R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Pen R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Parent | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *E. coli* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Penicillin**

| Strain | Dilution, 1: 5 | 10 | 20 | 40 | 50 | 80 | 100 | 150 | 200 | 300 | 400 | 500 | 600 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Staph. aureus* | | | | | | | | | | | | | |
| Pen R | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Sm R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 – | 1 | 1 | 1 | 2 |
| St R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 – | 1 | 2 |
| Parent | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 – | 1 | 1 | 2 |

Sm R = streptomycin resistant; St R = streptothricin resistant; Pen R = penicillin resistant.
Growth: 3 = good; 2 = fair; 1 = slight; 1 – = a few scattered colonies.

*In vivo* confirmation of the findings reported here would be highly significant to the clinician in the treatment of infectious diseases where penicillin fastness is encountered.

## *In Vitro* Action of Monopyridine Iodine (I) *p*-Nitrobenzoate Against Ringworm Fungi

JACOB KLEINBERG and ESTHER MEYER

*Department of Chemistry, College of Pharmacy,* and *Department of Bacteriology and Public Health, College of Medicine, University of Illinois*

In a previous report (*2*) it was demonstrated that compounds of positive univalent iodine, stabilized by coordination with pyridine, were toxic to some common pathogenic bacteria and to the saprophytic fungus, *Aspergillus niger*. The present communication deals with the action of various concentrations of the dry powder of monopyridine iodine (I) *p*-nitrobenzoate in sterile talc against the ringworm fungi, *Trichophyton gypseum* and *Microsporum audouini*. The evidence presented shows that low concentrations of the drug not only are effective against the above-mentioned fungi but also are extremely active toward the dried spores of these fungi.

### EXPERIMENTS WITH *T. gypseum*

Strain #9533, obtained from the American Type Culture Collection, was used in this portion of the work.

The fungicidal activity of the *p*-nitrobenzoate against the dried spores was determined in the following manner: A saline suspension containing 24,000,000 conidia/ml. was prepared as described in a proposed A.P.H.A. method for testing fungicides against *Trichophyton* (*1*). Sterile pieces (5 mm.$^2$) of Whatman filter paper No. 40 were soaked in this suspension and dried at 37.5° C. for two to six days. Duplicate dried impregnated papers were immersed in various concentrations (3, 5, 10, 15, 20, 25, and 50 per cent) of the dry powder in sterile talc for intervals of 1, 5, and 10 minutes, after which they were washed twice in Sabouraud's liquid medium and deposited on Sabouraud's agar slants. Dry and washed controls were set up in duplicate. The slants were examined daily for two weeks. With two exceptions (10 per cent-5 minutes and 25 per cent-1 minute), no growth resulted from those papers which had been immersed in *p*-nitrobenzoate in concentrations of 10 per cent or greater. All controls grew out rapidly.

To test for fungistatic and fungicidal activity using the agar cup-plate method, the following experiments were performed: Sterile 9-cc. Petri dishes, in the center of which were sublimation rings, were filled with Sabouraud's agar. After the agar had hardened, the sublimation rings were removed and *T. gypseum* was streaked over the entire surface with a dry, sterile cotton swab. Then the cup was filled with the appropriate concentration of the drug in sterile talc. These plates were incubated at room temperature for approximately 10 days, and the zones of inhibition measured. The results are shown in Table 1. A portion

TABLE 1

FUNGISTATIC ACTION ON *T. gypseum* BY MONOPYRIDINE IODINE (I) *p*-NITROBENZOATE

| | | | | |
|---|---|---|---|---|
| Per cent drug ..... | 3 | 5 | 10 | 15 |
| Zone of inhibition* (in mm.) .. | 12 | 16 | 19 | 23 |

* The averages of triplicate plates.

of agar from the clear zone was transferred to a Sabouraud's glucose agar slant. The absence of growth on the slant after an incubation period of two weeks indicated that the compound is fungicidal toward *T. gypseum*.

### EXPERIMENTS WITH *M. audouini*

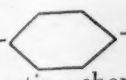
A saline suspension of conidia of a freshly isolated strain of *M. audouini* from a case of ringworm of the scalp was diluted to 18 per cent light transmittance as measured against a saline standard on a Lumetron photoelectric colorimeter, Model 400-G.[1] Sterile filter papers (5 mm.$^2$) were soaked in the suspension and dried for only 24 hours at 37.5° C., since the spores of *M. audouini* proved to be extremely sensitive to drying as compared to those of *T. gypseum*. Duplicate test papers were immersed in various concentrations (3, 5, 10, and 15 per cent) of the dry drug in sterile talc for intervals of 1, 5, and 10 minutes and treated as described previously for *T. gypseum*. At the time the slants were discarded after one month of observation, growth had occurred only in the controls and the papers treated with 3 per cent of the compound.

The agar cup-plate technique described for testing the fungistatic activity of monopyridine iodine (I) *p*-nitrobenzoate against *T. gypseum* proved less successful with *M. audouini*, since regular zones of inhibition could not be obtained because of the lack of uniform growth. However, the areas of inhibition in the case of the latter were greater than those obtained with the former for corresponding concentrations of compound.

### DISCUSSION

Monopyridine iodine (I) *p*-nitrobenzoate, I ($C_5H_5N$),

[1] It proved impossible to make a count of the conidia in a haemocytometer.



—$NO_2$, is an unusual compound, the iodine acting chemically as a positive ion. Hydrolysis or reduction produces elementary iodine.

It is probable that in the agar cup-plate tests against *M. gypseum* and *M. audouini* at least part of the activity of the compound is due to the liberation of iodine, as there is evidence that the latter is produced during the period of contact with the fungi. On the other hand, in the experiments with dried spores the role of free iodine is questionable.

The impregnated papers are in contact with the compound for very short periods of time, after which the excess drug is washed off. However, the usual difficulties in procedures of this sort are encountered. It is impossible to remove all of the active compound by washing, and there is always a possibility that traces of the drug remaining may exert some activity during the washing process. The filter papers, when tested after washing, give evidence of traces of positive iodine. The washing process itself produces no free iodine, since tests for this element in the wash solutions are negative.

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# *Letters to the Editor*

### Surface Measurements of Radioactive Phosphorus in Breast Tumors as a Possible Diagnostic Method

It has been shown repeatedly by assaying tissues that most experimental tumors take up relatively greater amounts of radiophosphorus ($P^{32}$) than normal tissues. In 1942 Marinelli and associate showed that after tracer doses of $P^{32}$ to three human cases the beta ray activity was measured on the surface was greater over cutaneous lesions than over normal skin.

It occurred to me that the energy of the beta rays from radioactive phosphorus was sufficiently great that, if tumors in the subcutaneous tissues took up more $P^{32}$ than the surrounding tissues, it should be possible to detect a difference by measurements on the skin surface. Therefore, in June 1945 preliminary investigations were started in the Division of Radiology, in cooperation with the Division of Surgery of the University of California Medical School, to study the differential uptake by breast tumors of tracer doses of $P^{32}$. The radioactivity on the surface of the skin over various types of breast tumors, over axillary nodes, and over supraclavicular nodes was measured with a Geiger-Müller counter a day or two before surgical removal. These measurements revealed that over tumors which were proven later to be malignant the activity was 25 per cent or more above that of comparative normal areas. Skin measurements over breast tumors which were later proven to be benign consistently showed less than 25 per cent difference between involved and uninvolved tissue. In March 1946 systematic studies were undertaken by comparing the activity measured on the skin surface over palpable breast tumors, adjacent areas of the same breast, comparative areas of the other breast, and the lymphatic drainage areas. In all but one of 25 patients the diagnosis based on preoperative surface measurements was confirmed by microscopical examination of the tissues after surgery.

These findings are so suggestive that this brief report is submitted with the hope that other investigators will try the method. A more detailed but still preliminary report on this subject will appear in the November 1946 issue of *Radiology*.

BERTRAM V. A. LOW-BEER
*Department of Radiology, University of California Hospital, San Francisco*

### On Eugen Fischer

The note about Eugen Fischer, professor of physical anthropology, University of Berlin, and director of the Kaiser Wilhelm-Institut für Physische Anthropologie (*Science*, 1946, **104**, 161) brings to mind that he was one of the leading Nazi anthropologists who are morally responsible for the persecution and extinction of the peoples and races the Nazis considered "inferior." He was the first Nazi rector of the University of Berlin and took over this post when decent scholars withdrew or refused to do business with the Nazis. His address delivered at the inauguration ceremonies (29 July 1933) was entitled: "The Conception of the 'Völkisch' (Nazi) State in the View of Biology." This address foreshadowed the official execution of the principles of "racial hygiene" as taught by the Nazis.

If anyone, he is the man who should be put on the list of war criminals.

FRANZ WEIDENREICH
*American Museum of Natural History*

### Effect of 2,4-Dichlorophenoxyacetic Acid on the Development of Anjou Pear Scald

The inhibiting action of growth-regulating chemicals on the development of apple scald has been reported by Schomer and Marth (*Bot. Gaz.*, 1945, **107**, 284–290). Treatment of apples at time of cold storage with α-naphthaleneacetic acid, β-indolebutyric acid, and a mixture of these two compounds with α-naphthalene acet-

amide and β-naphthoxyacetic acid resulted in a decrease in the amount of scald which developed when the fruits were transferred to a temperature of 70° F. That another type of scald which occurs on Anjou pears (Henry Hartman. *Ore. agric. exp. Sta. Bull.*, 1931, **280**, 1–8) can be controlled by treatment with 2,4-D is indicated by the results of experiments conducted during the 1945–46 season.

Anjou pears obtained from the Medford, Oregon, district were treated by immersion for 2–3 seconds in 0.1 per cent aqueous solutions of Carbowax 1500 containing 10, 100, 500, and 1,000 ppm 2,4-D. The control fruits were treated with 0.1 per cent Carbowax solution only. Following treatment, the fruits were allowed to dry, packed in plain paper wraps, and stored at 31° F. At 2-month intervals during a period of eight months samples from each treatment were transferred to 65° F. and ripened for 7–8 days.

No scald developed on any of the treated or untreated pears ripened following, 2, 4, or 6 months storage. After 8 months storage, however, severe scald developed during ripening on the control fruits and on the sample treated with 50 ppm of 2,4-D. None developed on the pears treated with 500- or 1,000-ppm solutions, and only a slight amount on the 100-ppm sample. While these data are considered to be preliminary, they indicate that 2,4-D used at an optimum concentration has a positive inhibiting action on the development of the type of scald peculiar to the Anjou pear.

In addition to the effect on the inhibition of scald, treatment with 2,4-D in concentrations of 100 ppm and higher resulted in the development of a more uniform yellow color during ripening. This was especially apparent on the samples ripened late in the storage season.

ELMER HANSEN

*Oregon State College, Corvallis*

## Comments on "A Relativistic Misconception"

C. Roland Eddy's Letter to the Editor (*Science*, 1946, **104**, 303) convinced me that the law of conservation of mass holds for elementary particles, but I must reserve doubts about this law applying to matter by the beakerful or universeful.

Most physical chemistry textbooks state that when an exothermic reaction takes place, there is a loss of mass that can be calculated from Einstein's equation, $E = mc^2$, and that this loss is much too small to be measured on present-day balances. This assertion is not incompatible with Mr. Eddy's statements concerning the conservation of mass in elementary particles, but the two points of view taken together lead to an interesting conclusion.

The reason that the reactants, when weighed in their beakers, should have less weight after reacting is that this weighing determines the sum of the *rest* masses of the particles, which sum *does* decrease when energy is released.

However, as Mr. Eddy has shown, the sum of the masses of the particles which have engaged in the reaction is the same. Increases in their velocities make up for decreases in their rest masses.

Therefore, except for bodies at a temperature of absolute zero, as far as mass is concerned the whole (mass of an entire body) is less than the sum of its parts (masses of the individual particles composing the body).

MARSHALL E. DEUTSCH

*2391 Davidson Avenue, New York City 53*

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The article by Eddy (*Science*, 1946, **104**, 303) was read with interest. It seems to the author that Eddy's views would have been much clearer if he had stated in what sense he was using the term mass. In current textbooks and articles, mass is used sometimes to mean quantity of matter, *i.e.* electrons, protons, neutrons, and various combinations of these elementary particles, and at other times mass is used to mean inertia. It is also to be noted that all matter has inertia and that radiation has inertia though radiation is not matter according to our present concepts.

Apparently Eddy, in his article, is using mass in both senses without distinguishing how the term is being used. For example, he says the equation $E = mc^2$ "does not state that a mass, *m*, can be converted into an energy, E . . ."; and later he says that "it was assumed that M is essentially at rest," where "*M* is the mass of the fissionable nucleus plus the neutron added to trigger it off." In these cases it is evident that mass is being used to mean matter. Near the end of the article he says that "the mass of a photon is $h\nu/c^2$," where evidently mass is used to mean inertia. Thus, would not the article be clearer if the term mass were used in only one sense, e.g. mass being defined as inertia? The main points of the article then would be as follows:

Einstein's equation, $E = mc^2$, states that a body of inertia (mass) *m*, can be converted into energy, *E*, and it also states that a body of inertia *m* contains an amount of energy, $E = mc^2$. Examples of the transfer of inertia of matter to energy are found in nuclear reactions and in the annihilation of a positron and an electron.

According to our present theory, when a fission occurs there are the same kind and number of elementary particles of matter after fission as before, but the sum of the inertias of the remaining particles is less than the sum of the inertias of the initial particles. The difference in these inertias is called the mass (inertia), *m*, that has disappeared; and the energy that appears in the form of kinetic energy and gamma radiation equals $mc^2$. This may be thought of as a transfer of energy from one form to another form, or as the mass (inertia), *m*, being converted into energy. The quantity of matter in this case remains unchanged.

According to our present theory, when a positron and an electron unite, these two pieces of matter disappear and usually two photons appear. If the positron and electron had no kinetic energy when they united, the energy of each photon equals $mc^2$, where *m* is the rest mass (inertia) of the electron as well as of the positron. This is another case of mass (inertia) *m* being converted into energy. But in this case matter disappears or is annihilated. The converse is also found to be true. A photon of sufficient energy in a strong electric field de

appears, and a positron and an electron appear. $E = 2mc^2$, where $E$ is the energy of the photon, and $2m$ is the sum of the inertias of the electron and of the positron formed. Energy in this case is converted into matter, and the inertia of the photon equals the inertia of the matter formed. In these two cases the quantity of matter is changed.

Hence, Eddy's conclusion that the law of conservation of mass (inertia) still holds is correct. But it is also correct that matter and energy are interconvertible, as evidenced in the cases where the positron and electron unite and disappear, the photon or photons appearing, and where the positron and electron appear at the disappearance of a photon. At least, these are the present interpretations of the experimental evidence.

VOLA P. BARTON

*Goucher College, Baltimore, Maryland*

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In a recent note (*Science*, 1946, **104**, 303), C. R. Eddy discusses a supposed "misconception in the minds of some scientists" concerning the meaning of the equation, $E = mc^2$, and the question of conservation of mass. To present a different view, I will recall a few definitions.

In proceeding from kinematics to dynamics, a third primary quantity is defined, namely, *rest mass* of a particle, denoted by $m_0$; the standard magnitude for this quantity is the rest mass of the International Kilogram. The secondary quantity, $m_0(1 - v^2/c^2)^{-\frac{1}{2}}$, is called the *relativistic mass* $m$ of a particle, by definition. Omitting all definitions not pertinent to the present discussion, we come next to definitions of energy. Various quantities having the dimensions $[ML^2T^{-2}]$ are defined in such a way as to satisfy a law of conservation of energy. Or, to put it another way, it has always been found possible to define physical quantities representing individual forms of energy such that the total energy of an isolated system is conserved, where, by definition, *total energy* is the sum of all the energy quantities of various types identified with the system. The following are examples of individual forms of energy encountered in one way or another: kinetic energy of a particle; potential energy of a conservative system; heat energy; internal energy of a thermodynamic system; radiant energy; energy of a photon; molecular, atomic, and nuclear binding energies; etc. Another such quantity of immediate interest is the quantity $mc^2$ which, for convenience, I shall call the *inertial energy* of a particle (kinetic energy plus rest energy $m_0c^2$). In atomic disintegrations there occurs a change in individual amounts of inertial energy, and frequently there occurs a transformation of inertial energy into radiant energy or vice versa. Energy and momentum are conserved in all instances. Now, what does $E = mc^2$ mean? A perfectly legitimate and fruitful point of view is this: In order to maintain the law of conservation of energy, the quantity $mc^2$ is called the inertial energy of a particle, by definition; letting $E$ denote this particular form of energy, the definition is expressed by the equation $E = mc^2$.

The conclusion of Eddy that "the law of conservation of mass still holds" is purely a question of definition. It may readily be seen that $m = m_0 + \Delta m$, where $\Delta m$ is a kinetic increment equal to the kinetic energy of a particle divided by $c^2$. In atomic disintegrations, rest mass $\Sigma m_0$ is not conserved in any case, and relativistic mass $\Sigma(m_0 + \Delta m)$ is not conserved when radiation is emitted. In the case of radiation, the quantity $h\nu/c^2$ has the dimension $[M]$. In accord with disintegration phenomena, $h\nu/c^2$ is called the *equivalent mass* of a photon. It is desirable to maintain a distinction between mass of a particle and equivalent mass of a photon in order to preserve appropriate distinction between matter and radiation. However, if we should choose to define a quantity, $Q$, having the dimension $[M]$, by the equation $Q = \Sigma(m_0 + \Delta m) + \Sigma h\nu/c^2$, we might then state a law of conservation of $Q$ (a quantity which Eddy calls the total mass). That this procedure is not accepted practice may not be attributed to a misconception on the part of those who do not follow it. Conservation of $Q$ is not employed as a specific law simply because association of the three types of quantities, $m_0$, $\Delta m$, and $h\nu/c^2$, on an equal basis would be a source of confusion without contributing anything toward clarification or simplification in our thinking; such conservation is already stated in more tangible terms by the laws of conservation of energy and momentum.

AUSTIN J. O'LEARY

*Department of Physics, The City College of New York*

## Use of Shorthand by Scientists

Have many scientists adopted the use of shorthand to save time and to enable them to make more complete notes?

Steinmetz learned a Swedish system at college and later developed a system of his own which he thought was better. Hugh Callendar, physicist, also developed a new system for his use, measuring the time required for making each symbol. Callendar's system was adopted in mid-life by his colleague, Sir Joseph Thomson.

It would be interesting to have other instances reported in this section of *Science*.

DONALD A. LAIRD

*Homewood, Lebanon, Indiana*

## Correction on the Nomenclature of Human Plasmodium

In the nomenclatorial and zoological confusion in the names for the human malaria parasites (Sabrosky and Usinger. *Science*, 1944, **100**, 190–192; Beltran. *Gaceta Med. Mexico*, 1944, **74**, 61–74), one further point has been discovered.

It has usually been considered that there were only two different proposals involving *malariae* as a new specific name—*Oscillaria malariae* Laveran, 1881, and *Haemamoeba malariae* Feletti and Grassi, 1890. Actually it now appears that there were *three*!

Careful reading of Marchiafava and Celli (*Fortschr. Med.*, 1885, 3, 791–797) shows that they too were proposing what they regarded as a distinct new form, quite unlike any previously described: "Aus dem Gesagten geht hervor, dass die beschriebenen Körperchen nicht verwechselt werden dürfen mit irgend welchen zufälligen oder pathologischen Dingen, die man bisher in den roten Blutscheiben bemerkt hat. . . . so scheint es uns nicht fernliegend, sie als parasitäre Organismen anzusprechen und

ihnen den Namen *Plasmodium malariae* zu geben.'' The name was italicized and unquestionably intended as a formal scientific name. This proposal of *Plasmodium* as a new generic name has been accepted, but the new specific name has apparently been quite generally overlooked.

Of the three identical specific names, it is now generally agreed that *malariae* Laveran applies only to the parasite of *falciparum* or malignant malaria. *Malariae* F. & G., which originally included both quartan and tertian parasites, was later restricted by Grassi and Feletti (*Arch. ital. biol.*, 1890, 13, 300) to the quartan parasite, at which time they named the tertian parasite *vivax*.

The situation is not so clear, however, with reference to the *malariae* of Marchiafava and Celli (1885). Their detailed descriptions, case histories, and figures in Plate VI have been critically analyzed by Martin Young, of the National Institute of Health, as follows:

''It seems to me definitely that most of the infections that they saw were *falciparum*. However, they seem occasionally to have run across a *vivax* infection. Some of the descriptions are definitely of *vivax* segmenters while others of the descriptions, especially where they mention the finding of crescents, are definitely *falciparum*.

''The generalized figures on the plate are difficult to identify, with some suggestive of both *vivax* and *falciparum*. The confusion arises from the fact that some of the cases they were looking at were very severe infections of *falciparum*. In such cases, it is not uncommon for the developmental forms of *falciparum* to be found in the blood stream. Therefore, from pictures with so little detail, it is hard to tell whether the forms shown are young stages of *vivax* or older stages of *falciparum*.''

Throughout the paper, Marchiafava and Celli referred frequently to such characteristics of *falciparum* or malignant malaria as the comatose fever, rapid onset of death, remarkable numbers of parasites (especially in the capillaries of the brain), and the presence of crescents. Besides this evidence, it may be noted that their cases originated during a very severe epidemic in Rome and the Pontine Marshes, where *falciparum* is the principal species of malaria.

There seems little doubt, therefore, that *Plasmodium malariae* M. & C. was based mainly on the malignant tertian parasite (*falciparum*). The benign tertian parasite (*vivax*) was seen, but there is no evidence of quartan.

If *malariae* M. & C. be considered to represent one species only, then the malignant tertian form would have to be considered the genotype of *Plasmodium*, in which case *Oscillaria* Lav., *Plasmodium* M. & C., and *Laverania* F. & G. are isogenotypic, all based on the same species (properly called *malariae* Lav. under strict interpretation of the Rules of Nomenclature, but generally known as *falciparum*).

On the other hand, if *malariae* M. & C. be regarded as originally composed of two species, it would then appear that the type has never been restricted to a single entity because the species name has been so long overlooked. Even though the malignant tertian parasite is unquestionably the major basis of Marchiafava and Celli's description, it appears that at this late date considerable confusion could be avoided by restricting the name *malariae* M. & C. to the benign tertian form. If such action were taken, and considering that all the human malaria parasites are congeneric (as they are usually regarded), the name would then be a homonym, and the correct name would be the next valid and available name, hence *vivax* G. & F., 1890 (= *malariae* M. & C., 1885, nec *malariae* Lav., 1881). Thus (1) *vivax* would become the genotype of *Plasmodium* M. & C.; (2) it would not be necessary to suspend the Rules of Nomenclature in order to designate a type for *Plasmodium*; and (3) the status of *Laverania* as a possible generic name for the malignant parasite (if segregated) would not be disturbed.

In order not to complicate any other action by the International Commission on Zoological Nomenclature, formal designation of the above is withheld, and it is presented as a suggestion to be considered as a part of the whole problem.

CURTIS W. SABROSKY
*U. S. National Museum, Washington, D. C.*

## Radioactive Hydrocarbons

In connection with our studies involving Carbon 13, we became interested in the radioactive carbon isotope of long half-life, C 14 (S. Ruben and M. D. Kamen. *Phys. Rev.*, 1941, **59**, 349–354). Through the kindness of J. R. Dunning, of Columbia University, we received a small amount of C 14 prepared by bombarding C 13 with deuterons or N 14 with neutrons from the Columbia cyclotron. Subsequently, very much larger quantities prepared in the Oak Ridge uranium pile were made available to us.

Among the various types of radiocarbon compounds prepared were radioactive hydrocarbons. In view of their interest for the study of hydrocarbon reactions, the synthesis of *radiomesitylene* is described herein.

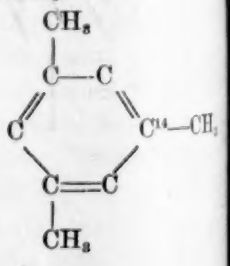
Starting with $BaC^{14}O_3$ the sequence of reactions was the following:

(1) $C^{14}O_2 + CH_3MgI \longrightarrow CH_3 \cdot C^{14}OOH$

(2) $CH_3 \cdot C^{14}OOH + Ba(OH)_2 \longrightarrow Ba(C^{14}O_2 \cdot CH_3)_2$

(3) $Ba(C^{14}O_2 \cdot CH_3)_2 \xrightarrow[500^\circ\ C.]{\text{vacuum}} CH_3 \cdot C^{14}O \cdot CH_3 + BaC^{14}O_3$

(4) $CH_3C^{14}OCH_3 + 2\ CH_3CO \cdot CH_3 \xrightarrow{H_2SO_4}$




This radiomesitylene may appropriately be called *1,3,5-trimethyl-radio-1-benzene*. The probability of forming the di- and tri-radiobenzene was negligible with our concentration of C 14.

The first three steps gave yields of 94, 100, and 95

cent, respectively, or an over-all yield of 89 per cent. 432 mg. of radio-2-acetone thus obtained were diluted 1.20 gram of ordinary acetone as a carrier and ensed with sulfuric acid essentially according to the edure in *Organic syntheses* (Collective Vol. I. New : Wiley, 1941. P. 341), adapted to small quan-. The 296 mg. of distillate were diluted with 865 of ordinary mesitylene as a carrier, purified by ration and recrystallization of the monosulfonic (melting point, 74–75° C.), which was then decom- with HCl, and steam-distilled. The distillate was y distilled in a high vacuum over sodium. The prod- weighed 672 mg. and had a n D/20° = 1.4976, as nst a recorded value of 1.4967.

The radioactivity was measured in a thin-window, scale-of-64 Geiger counter. The values obtained, corrected for absorption and geometry, were: for radio-1-acetic acid, $270 \cdot 10^6$ disintegrations per minute and per gram carbon; for radiomesitylene, $6.3 \cdot 10^6$ disintegrations per minute and per gram carbon. The radioactivity of the mesitylene indicates a 10-per cent yield, based on acetone.

Part of the mesitylene was converted into *1,3,5-trimethyl-radio-1-cyclohexane* by catalytic hydrogenation (by W. Fowkes) under pressure in a microbomb.

A. V. GROSSE and S. WEINHOUSE
*Houdry Laboratories*
*Houdry Process Corporation of Pennsylvania*
*Marcus Hook, Pennsylvania*

# Book Reviews

***electron microscope: an introduction to its fundamental principles and applications.*** **(2nd ed.) E. F. Burton and W. H. Kohl. New York: Reinhold, 1946. Pp. 35. (Illustrated.) $4.00.**

Prior to the late 1930's the development of the electron microscope was confined to Germany and Belgium, as a consequence we find that the early books treating this instrument are written in German. The University of Toronto was the first institution on this continent attempt to duplicate and improve upon the work of European physicists, and the guiding force behind successful effort at Toronto is the senior author of present volume, Prof. Burton. With the exception certain treatises on electron optics, the first book in lish devoted to electron microscopy was the first ion of *The electron microscope,* published in 1942. the intervening four years there have appeared in country two other books on electron optics and roscopy: *Seeing the invisible,* by Gessner G. Hawley, *Electron optics and the electron microscope,* by rykin, Morton, Ramberg, Hillier, and Vance, all of RCA staff. The former volume is so elementary as e of interest only to the generally curious and unical reader, while the latter is very thorough and ematically rigorous. The second edition of Burton Kohl's *The electron microscope* is nicely balanced een these two extremes and should be of use and rest to those whose work is connected with electron roscopy but whose training in mathematics and physs not advanced. There are many persons working r directly or indirectly with the microscope, or conplating the use of the instrument, who would like to enough about it to comprehend its possibilities and tations but who do not care to become experts in the y, construction, and operation of such a highly alized instrument. It is to these persons, as well those of training sufficient to afford them a genuintelligent curiosity about the electron microscope, that the book is directed.

For the most part the book rearranges and enlarges upon the material contained in the first edition. Electron microscopy has advanced rapidly in America since 1942, and the authors have expanded certain chapters and have written new ones in a conscientious effort to keep up with current research. The chapters on electrostatic lenses and microscopes have been reduced in length, and those on magnetic microscopes have been extended to reflect the relative success in this country of the magnetic type of instrument.

The contents of the book can be reviewed under four major divisions. In the first the principles of geometric and physical optics are developed with particular reference to the compound light microscope and to the meanings of magnifying power and resolving power. In the second division the wave nature of the electron is introduced and discussed, and the fundamentals of electron optics are elaborated. The geometry of the focusing action of electrostatic and magnetic lenses is derived from elementary notions, with constant reference to analogies with the light microscope. The third general division is given to an explanation of the construction and operation of the complete electron microscope, the University of Toronto microscope of 1944 being used as an example. Here the authors may be accused of myopia, since all instruments in use on this continent, with the exception of three, are those made by RCA. A detailed description of the commercially available microscope would have been more generally useful to the readers. In the last section of the book one finds an excellent résumé of the research work which has been done with the aid of the electron microscope. This discussion is ample for a book of this size, and it has been critically written and profusely illustrated with about 50 half-tone plates. As an appendix to the book there is reprinted the bibliography of electron microscopy by Marton and Sass, brought up to date to the end of 1944.

Aside from a few fundamental formulas, one finds no mathematics in the book. Instead, the authors have attempted to explain the ways of electrons with words and well-designed drawings. It is perhaps not generally recognized by physicists, hardened to the frequent use of equations, that the easy way for authors lies in the use of equations and symbols. Burton and Kohl will be thanked by the nonmathematical reader for their very real effort to explain physical phenomena in words and pictures instead of symbols.

ROBLEY C. WILLIAMS
*Physics Department, University of Michigan*

***Advancing fronts in chemistry.*** **Vol. II: *Chemotherapy.* Wendell H. Powers. (Ed.) New York: Reinhold, 1946. Pp. 156. (Illustrated.) $3.25.**

This volume is a collection of lectures delivered in 1945 as a symposium at Wayne University. The scope is indicated by the chapter titles. Chapter I, by W. H. Feldman, covers "Chemotherapy in Experimental Tuberculosis." One is impressed by the relative paucity of significant results attained in this field, and as a result the chapter deals principally with work with the sulfones, largely by the chapter's author and co-workers.

Chapter II, by F. H. Blicke, covers "Antispasmodics." One may question the presence of this chapter in a work on chemotherapy, but the presentation is an interesting example of how the chemists have juggled leads, in this case principally tropic acid and tropine, to evolve synthetics with more desirable properties than those of the natural compounds first known to have antispasmodic effect.

Chapter III, by E. H. Northey, deals with the sulfa drugs and includes an adequate consideration of the ideas of competition between prevailing drugs and a related "essential metabolite" for a place in the economy of the bacterial invader. Other theories of the mechanism of the action of the sulfa drugs are also considered.

"The Antimalarial Problem," by H. S. Mosher, is the subject matter of Chapter IV. In addition to chemicals used for treatment and prophylaxis, methods of control by sanitary means and chemical extermination of the insect carriers are considered. Brief mention is given the notion that the antimalarial drugs may act as the sulfonamides may act, *i.e.* by competition with some metabolite essential to the growth of the malarial parasite.

C. K. Banks contributes a chapter on "Organometallic Compounds as Chemotherapeutic Agents." With relatively brief space available for each metal, a satisfactory outline is given of the uses of the compounds of arsenic, antimony, mercury, bismuth, gold, and silver in the treatment of infections.

The last chapter, by W. H. Wright, on "Past and Present Needs in Chemotherapy of Parasitic Diseases" is the most detailed chapter, as well as the longest (42 pp.). In fullness it more nearly approaches a monograph than does any other chapter. There is necessarily some overlapping of subject matter with the preceding chapter.

The absence of a chapter on antibiotics is a glar hiatus. This subject was covered in the symposium a lecture by H. E. Carter, but the editor explains in Preface that the author was unable to prepare the lec for inclusion in the book.

As is probably inevitable in a symposium, there some variation in the degree of excellence of presenta among the different chapters. However, in all cases th is a satisfactory pharmacological color, in that the a tion of chemical considerations and biological proble always borne in mind and made clear.

While the book is in no sense a monument of refere it will be a very useful starting point for chemical dents wishing to become acquainted with the pre status of chemotherapy. The full references at the of each chapter will be ample keys for those wishing explore the subject in full detail.

EDWIN C. WH
*713 Lake Drive, Baltimore, Maryland*

***Photometric atlas of stellar spectra.*** **W. A. Hiltner R. C. Williams. Ann Arbor, Mich.: Univ. Michi Press, 1946. Books I–IX. (Illustrated.) $7.50.**

The University of Michigan possesses a microphot eter, constructed by Williams and Hiltner, which the property of recording spectra on a direct inten scale (for description see *Publ. Observ. Univ. Mich.*, 8, 45).

The first major batch of results is before us in *Photometric atlas of stellar spectra,* published in form of nine separate booklets, held together in a st folder. Marvelous tracings of the spectra of α Boo α Cygui, β Orionis, α Lyrae, α Canis Majoris, α Ca Minoris, α Persei, and α Orionis fill Books II to and Book I contains general information concerning use of the *Atlas.* The stellar spectra were photograp with the Coudé spectrograph of the 82-inch reflector the McDonald Observatory of the University of Te while the star image was driven very slowly along 0.05-mm.-wide slit of the spectrograph. The length the slit was at the most 3.0 mm., and the maximum len of the analyzing slit of the microphotometer was 2.5 m

The tracings in the *Atlas,* reduced to one half originals, show a magnification of 21.6 with respect the spectrograms, and the dispersion ranges from (mm./A.U.) in the violet to 2.5 in the red. The inten scale, reproduced with each tracing, permits reading 1 per cent (corresponding to about 0.5 mm.), and represents, as the authors point out, the real accura of the intensities. It is, perhaps, somewhat unexpe that the wave lengths are indicated only at the ends the tracings; a wave-length scale would have been c venient to many students in this field.

To say that spectroscopists will welcome the *Atla* doubtless an understatement, since it is the first t that stellar spectra have been made available on a s hitherto possible only for the sun.

JAN SCH
*Department of Astronomy, Columbia University*